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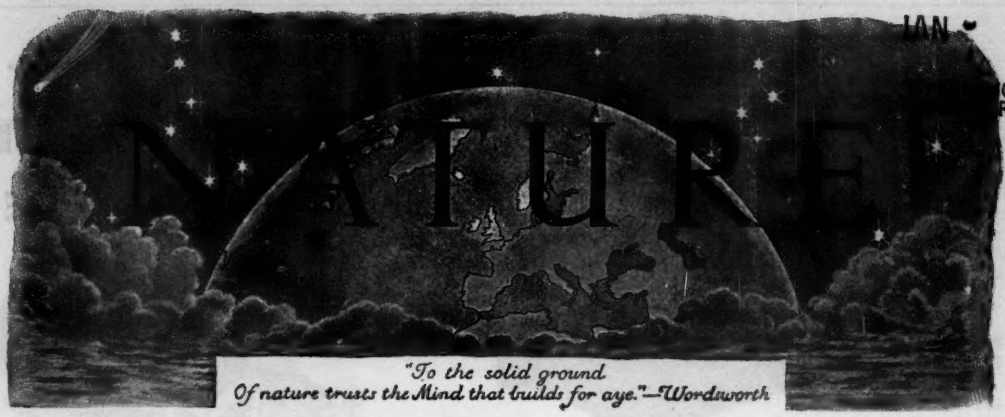

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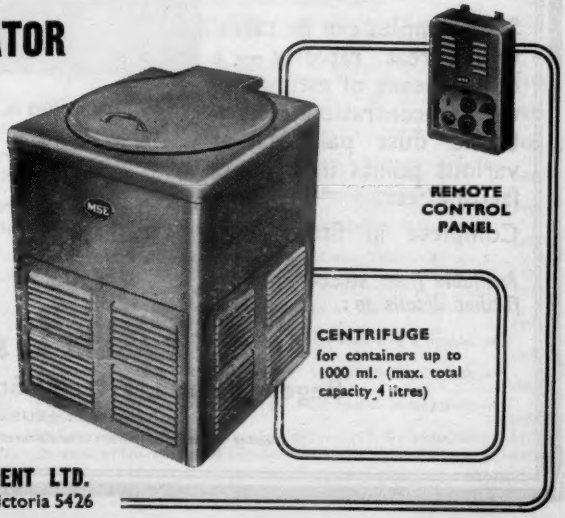

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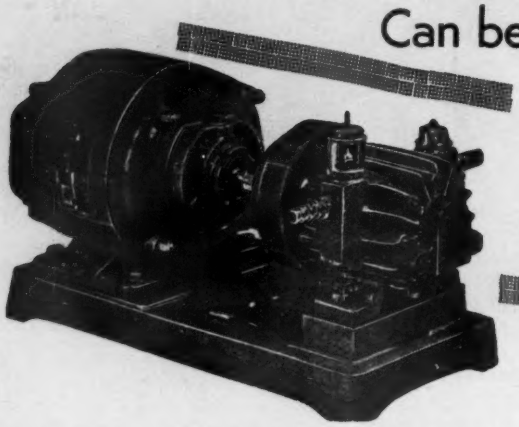

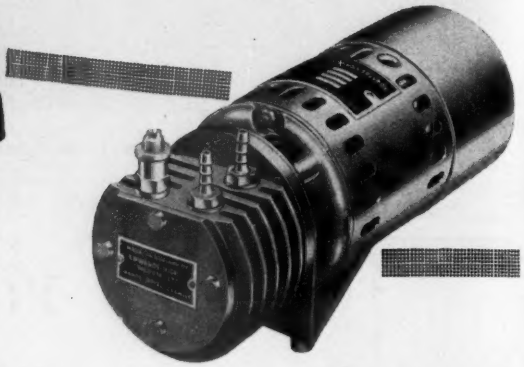

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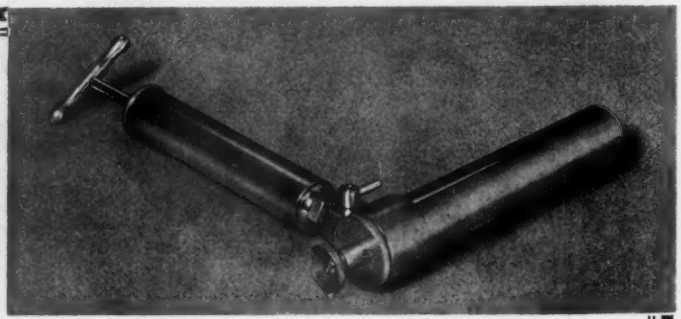

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PUBLIC CONFIDENCE AND SCIENTIFIC DEVELOPMENT

"THE important thing for this country to-day is that people should come to realize first, that science is not latter-day witchcraft but simply a process of disciplined thought and experiment; and second, that technology is neither a mystery nor beneath contempt but simply the translation of knowledge into practical advantages in everyday life." Those words from the conclusion of the Duke of Edinburgh's speech on opening the new extensions of the Manchester College of Science and Technology on November 22 should be borne in mind in considering the recent accident at the Windscale factory of the Atomic Energy Authority. If Britain is to enjoy the full advantages of the developments made possible by the work of her scientists and technologists, those developments must be broadly understood by the people at large, who must have a general appreciation of the price to be paid.

It was argued quite reasonably by Mr. D. Renton, replying for the Minister of Power in the House of Commons on November 11, that if public confidence was shaken at all by what happened at Windscale, so far as Calder Hall and the Electricity Authority's nuclear power stations are concerned, confidence should be completely restored by what is set forth in the White Paper (see *Nature*, November 23, p. 1093) and by the Prime Minister's statement of November 8. Nevertheless, the question of public confidence in regard to technological development generally is the over-riding issue raised by the whole incident, and it was well brought out in the debate in the House of Lords on November 21. Lord Lawson, on whose motion the debate was opened, commented on the sense of responsibility which he observed in the whole bearing of those who worked at Windscale, and said that work such as is being done at Windscale and Calder Hall could not continue in an area where people harbour any feeling of grievance against those who are operating the factories concerned.

Lord Lawson recognized that the three committees appointed to evaluate the technical observations derived from the accident and to recommend any necessary measures to remedy defects in organization —in relation to the operation of reactors in the Atomic Energy Authority's Research Group, in the control of health and safety generally, or to the controlled release of Wigner energy in particular—are likely to lead to arrangements which will ensure that repetition of such an accident is improbable, and that the choice of Sir Alexander Fleck as chairman should guarantee that there is no undue delay. Nevertheless, he was somewhat critical of the Authority's safety organization, though his main point was that staff of the appropriate calibre and insight could do much to engender the general confidence which he stressed as so important.

It is here, of course, that security considerations make it difficult to remove all misgivings, as the publication of the full report might have done. There can be little doubt that the Prime Minister is right to withhold publication on security grounds, but the technical character of the report does not affect the consideration that secrecy is always a stumbling-block to establishing public confidence and understanding. To ensure confidence, prudence requires that the limits of secrecy should be kept under continuous scrutiny and revised from time to time. The fullest possible publicity is the surest way of securing public understanding and goodwill in such enterprises, and public confidence rests rather on the positive achievements of the scientists and technologists and others responsible than on negative measures or concepts.

This much was implied in Viscount Stonehaven's view that wide publicity should be given to the fact that future nuclear power plants are being built on a totally different principle, and that this kind of accident could not occur in the closed cycle, carbon dioxide cooling system now being used. Lord Rea also urged that the Minister and the Government should take the public more into their confidence, while Lord Glyn, who referred to the utmost importance of a sense of proportion in regard to the accident, said that the real danger is that it might affect public opinion throughout the country. It would be a disaster if people got the idea that there is a danger wherever a new establishment is erected. It should be emphasized that there is no reason for believing that the new establishments being set up by the Atomic Energy Authority, with outside organizations, are a source of danger to the public.

The debate in the House of Lords went far to provide the reassurance which Lord Glyn suggested should be provided whenever this question is discussed. Lord Glyn himself paid a tribute to those who had carried out all this development without serious accident, and Lord Mills amplified it; and both the Prime Minister and Mr. Gaitskell in the House of Commons gave generous acknowledgment to the courage, energy and resourcefulness of those at the installation after the accident, Mr. Macmillan agreeing with Mr. Woodburn that heroism on the part of some scientists had averted real disaster. Although the accident may have been due to human error, the vigour with which it was dealt with, and the standards of responsibility and the skill and judgment which have made possible Britain's ambitious nuclear power programme, and enabled it to operate until the accident at Windscale without a single serious accident, constitute a firm basis for continuing public confidence. Even after this serious accident, the Atomic Energy Authority can still say that all this has been done without anyone being hurt, let alone killed, by radiation from one of its plants. This background of swift progress, safety and success must not be forgotten, and it provides the right perspective when we are seeking to determine just where the fault lay, how it can be remedied and what can be learned from the accident. Nevertheless,

the public may well ask whether the Authority may be too complacent in future about other unsuspected dangers as great and as insidious.

Here the frankness of the White Paper is reassuring, though it is still possible to wonder whether secrecy might have been relaxed a little further in the effort to dispel public anxiety. Lord Mills was no less frank in his reply to the debate on November 21, and although he added nothing technically substantial to what was in the White Paper, he indicated that Sir Alexander Fleck's three committees were already at work. He agreed to consider suggestions that more should be done to inform and advise the local population, but pointed out that this was not overlooked by those in charge at Windscale even at the height of the incident. The Atomic Energy Authority is not satisfied, however, that the arrangements for local liaison are entirely satisfactory, although relations between the Windscale management and all local organizations in Cumberland are excellent. The Authority has now decided to put relations between all its works and local interests on a more comprehensive basis, and liaison committees are now being formed, on which the steps to be taken in an emergency will be fully studied with all the local interests which might be concerned.

Lord Mills added that the Agricultural Research Council and the Ministry of Agriculture have been conducting very intensive research into the effect of radioactive fall-out on grass and crops, and he was sure that they will have full regard to points as to strontium-90 and marketing arrangements made by Lord Alexander of Hillsborough. Under the Atomic Energy Act, 1954, the Authority has an absolute duty to ensure that no ionizing radiations from anything on any premises occupied by it causes any hurt to any person or any damage to any property, and it has announced that it will consider claims from persons who can produce evidence that they have suffered harm.

As Minister of Power, Lord Mills is closely concerned that nothing should prejudice the continued success of the nuclear power programme of Britain; but in conclusion he claimed that the debate had shown that confidence in the country's nuclear future is fully justified. He repeated the conclusion of the White Paper that the accident at Windscale could not happen with the Calder Hall reactors, or with the reactors being built for the electricity authorities. He claimed that there is nothing in the Windscale accident which need make our policy for siting nuclear power stations more restrictive, and he repeated that proper arrangements for any emergency would be available for all such stations. The lessons to be learnt from the Windscale incident, he said, will be carefully applied to the nuclear power stations to be erected and operated by the Electricity Authority.

Until Sir Alexander Fleck's committees report, it is improbable that anything further can be added to the White Paper and what has already been said in Parliament. Meanwhile, however, three points already noted there should be kept in mind. First, there is the desirability of keeping secrecy to a minimum. Secondly, a considered policy in relation to the siting of nuclear power plants and other nuclear energy establishments, particularly when a threat to Nature reserves, national parks or other amenities is involved, would go far to avert public suspicion and opposition. Neither Mr. Renton nor Lord Mills seemed sufficiently to appreciate the importance of this point, that no Authority should be judge in its own interest, or the bearing of this principle on public confidence. Thirdly, the vital importance of staff of the highest calibre, not merely technically competent but also alive to the human and other issues involved, cannot be over-emphasized. To obtain, and retain, such staff, it is essential not merely that conditions of service, including salaries, as Lord Rea emphasized, should be satisfactory, but also that the educational system should be providing a supply of technologists such as the Duke of Edinburgh urged—well educated and not simply specialists—and that they should enjoy the respect and understanding of the community as a whole.

PRE-FAMINE IRELAND

Pre-Famine Ireland

A Study in Historical Geography. By T. W. Freeman. Pp. viii+352. (Manchester: Manchester University Press, 1957.) 35*s*. net.

MUCH has been written by historians on the social and economic conditions in Ireland during the middle of the nineteenth century, when the disastrous famine of 1845–52 permanently changed the face of the countryside and started the decline in population which has continued to the present day. T. W. Freeman, however, is the first geographer to make a detailed study of the period, and in this book he gives a lively factual account of life and landscape in the country just before the onset of the famine. He is fortunate in having abundant material upon which to draw. 1842 saw the completion for Ireland of the first set of Ordnance Survey maps to cover any country on a scale of six inches to one mile; the population census of 1841 was the most reliable yet taken for the country and was much more than just a simple enumeration of people; while the reports of numerous commissions, notably that under the chairmanship of Lord Devon, gave accurate and sympathetic reviews of social and agricultural conditions throughout the country. Mr. Freeman has handled this material with skill, and, where possible, has plotted his data to produce interesting distribution maps of such diverse matters as population density, house types and illiteracy.

The book is divided into two sections. Part 1 deals systematically with population, emigration, agriculture, trade, communications and social problems. The picture which emerges is a grim one. By 1841 the population exceeded 8 million, and of these, three-quarters were tenant farmers attempting to gain a living from the land. Long-continued subdivision of the farms had reduced many of the holdings to such a size that they could no longer support a family, even taking into account the high yield of the potato, which was the basic item of diet. Many lived in extreme poverty, especially those who

were landless, for there was little prospect of employment and the alternatives were starvation or emigration. Thousands of emigrants found their way into the growing industrial towns of Great Britain and the United States of America.

The chapter on agriculture in this section is relatively short and might have been expanded with profit. That on trade is more exhaustive and includes a full discussion on mineral resources and industry; while the chapter on communications is a model of its kind.

Part 2 is a detailed regional analysis of the country. There are maps to show the distribution of demesne land and rough pasture; and also population density. The latter are of special interest for they indicate that practically all the habitable part of the western seaboard had a density of population exceeding 400 per square mile. These regional studies are useful to anyone interested in specific parts of the country; but they also serve to show the wide difference that existed between, for example, the Provinces of Connaught and Leinster, and between the industrialized north-east and the remainder of the country where industry, though widely distributed, was of very little real significance.

The arrangement of this book gives rise, inevitably, to some repetition, and a few of the maps have suffered from over-reduction, but these are relatively minor points which do not obscure the fact that Mr. Freeman has made a substantial and lasting contribution to the historical geography of Ireland.

J. P. Haughton

ECONOMICS AND COMMON SENSE

Economic Analysis

By Prof. Edmund Whittaker. Pp. xiii+460. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 52*s*. net.

PROF. E. WHITTAKER starts his consideration from the choices before individuals, farmers, businesses, voluntary groups and organs of government. This enables him to raise in his readers' minds the economic questions which may legitimately be asked. He sets out the quantities by which decisions should be guided and only introduces, as the argument proceeds, the terminology of the economist. He explains why, for example, a textile mill might be sold up while still a going concern; and points out that a proper policy for conservation is not always that one which guards the interest of the future by preventing too rapid an exploitation of natural resources in the present. It was perhaps not necessary to provide for the incompetence of the farmer who sows his seed so thickly that the crop does not ripen (pp. 224 and 225); and the reviewer, for one, would have liked to learn more of the reasons why, on p. 195, a family was supposed to value at 80 dollars the exhilarating experience of watching "the telly" for a month. But these objections are by the way. Prof. Whittaker asks questions and gives answers acceptable to most social scientists. His illustrations, however, are so peculiarly North American and drawn so often from farming that their significance may be lost on readers not well acquainted with the customs and constitution of the United States of America nor familiar with the techniques of agriculture. Surely, too, some more elegant way could have been found of expressing what was meant than by those inversions designed to avoid prepositions which so irritated at least one English reader. "Favorable purchase opportunities" on p. 203 is one example, and the reviewer would have been quite mystified by the "adjustment of land-labor proportionality called for by altered production and market conditions" on p. 218 had he not already known about the enclosures of common land in England during the eighteenth century.

An impressive mass of material is collected by departments of government in the United States, by agricultural stations, firms, universities and other research institutions. (The American economist is far better served in this than his British counterpart.) The hopes of the scientist for economics will be raised by this wealth of data. But they will certainly be dashed by the dependence of economic analysis (which the author does not attempt to disguise) upon the vulgar prejudices of common sense.

The book is designed, as the author tells us in his preface, to serve as a text for undergraduates taking the economic analysis and theory offered in American colleges after an introductory course. Prof. Whittaker insists that economic problems involve the interaction of more than those two variables to which most academic economists, faced with a class and a blackboard, have been content to confine themselves. But scientists will not gain much from the graphical representation of a three-variable analysis nor will they find in Prof. Whittaker's pages any detailed treatment of those fascinating issues upon which, without assistance from electronic computers and multi-channel analogue machines, six economists have so comfortably maintained their seven opinions. All these must be sought in the works which Prof. Whittaker has included in the bibliographies appended to his chapters.

Gilbert Walker

MIDDLE-EASTERN APHIDOIDEA

The Aphidoidea of the Middle East

By F. S. Bodenheimer and E. Swirski. Pp. iv+378. (Jerusalem: The Weizmann Science Press of Israel, 1957.) n.p.

THE importance of aphids as economic pests and as virus vectors has led to a considerable amount of research on this group in recent years and to a corresponding increase in the already large volume of aphid literature. This, however, is mostly in the form of specialist papers in a variety of journals, and up-to-date comprehensive works are comparatively few. A careful and well-documented study of the biology and systematics of the aphids of a geographical region such as the Middle East, which Prof. Bodenheimer and Dr. Swirski have produced, is therefore to be welcomed, particularly as the aphids of this area have never been studied intensively before.

The authors state at the outset that their aims are to help the taxonomist and the agricultural entomologist to identify aphids, and to suggest further lines of research into aphid ecology. The first half of the book deals with life-history studies, the problems of migration and host-finding, nutrition, climatic influences, and the relationships of aphids with ants and with predators, together with a brief chapter on aphid damage and control. In most of their eco-

logical studies, carried out in Israel, Prof. Bodenheimer's team of workers have applied methods worked out by European aphidologists, whose work is freely quoted and discussed, and the chief interest of the book lies in the new light it throws on the behaviour of aphids in an arid, subtropical climate.

Most aphids are best suited to life in a temperate climate, and in those that occur in the tropics it is usual to find that the sexual phase of the life-cycle, with the laying of over-wintering diapause eggs, has been suppressed. In order to survive, such anholocyclic species must have a continuous supply of suitable food. In arid zones such as Israel, nearly all suitable aphid host plants are dry and dead during the summer and autumn, and for long it was unknown how aphids, which regularly infest plants in the spring growing period, survive the dry season. The authors find that this is effected for the most part either by a few individuals which chance to find sheltered conditions favourable to survival, or, in the case of root feeders, by refuge in ants' nests at considerable depths below the soil surface. In either case, the mortality of such species at the onset of the dry season is enormous. In some groups, however, notably the Fordinae, which migrate between *Pistacia* species and the roots of grasses, there is a true holocycle, complete with sexual phase and the laying of diapause eggs, which is adapted to withstand conditions of this sort. The cycle lasts for two years, one of which is passed as diapause eggs. For the remainder, the developing colonies live either in enclosed leaf-galls, which offer protection against predators and prevent evaporation, besides providing suitable food at times when normal foliage does not, or below ground on grass roots. The critical change-over from primary to secondary host takes place in the autumn, when the winged migrants leave the *Pistacia* galls and deposit their young on the soil or under stones, where they remain quiescent and unfed for some weeks until the grass seeds germinate with the coming of the first rains.

The second half of the book comprises keys for the identification of Middle Eastern aphids and a systematic list of the two hundred species so far recorded from the region, with notes on the synonymy, bibliography, hosts, distribution and life-histories of each. The system of nomenclature follows that of Börner, and is in line with that adopted by most European aphidologists. The keys appear to be soundly constructed, but are, of course, valid only for the limited number of species they cover. It is unfortunate, though probably unavoidable, that in the Pemphiginae and some of the Fordinae, the keys run down to genera but no further. A separate key to the galls of these species, however, makes good this deficiency to some extent. The section ends with a host plant list and a good bibliography.

The book is printed in good, clear type, but the paper does less than justice to the illustrations, especially those in half-tone. Some of the graphs and diagrams are insufficiently explained, and the index is confined to specific names of aphids only, omitting references to subjects or authors dealt with in the text.

Nevertheless, the authors succeed in achieving considerably more than their modest aims suggest, and by presenting the results of original research together with a résumé of much recent work by European specialists, they make a contribution of real value to entomology as a whole.

J. P. Doncaster

TRIBAL GOVERNMENT

Government and Politics in Tribal Societies

By Prof. I. Schapera. (Josiah Mason Lectures delivered at the University of Birmingham.) Pp. viii+238. (London : C. A. Watts and Co., Ltd., 1956.) 21*s*. net.

THE present volume, based on the Josiah Mason Lectures delivered by Prof. I. Schapera at the University of Birmingham in 1950, sets out to compare the traditional forms of government that had been developed among the indigenous peoples of South Africa—the Bantu, Hottentots, Bergdama and Bushmen—in pre-colonial times. Each of these peoples had its own distinctive mode of life, ranging from the food-gathering economy and nomadic existence of the Bushmen to that of the agricultural and more sedentary Bantu ; there were also important differences between the 'communities' in terms of population size and distribution as well as in forms of local grouping. However, Prof. Schapera finds a unit of comparison in the concept of the 'political community'. The 'political community' is defined by reference to exclusive rights to a given territory, the members sharing other rights and obligations that do not extend to outsiders ; but the distinctive criterion is that the 'political community' manages its own affairs independently of external control. On this basis, the author has been able to examine for each of his major divisions in turn what leaders there are, the qualifications for and requirements of office, the activities and functions of the governors, their privileges and powers and the limitations on the exercise of these powers, and a number of other related questions. His summary of the data suggests, in a number of propositions, the relationship between forms of political behaviour and increasing social and economic differentiation.

In the original lectures the illustrations were selected from a wide range of peoples in many different parts of the world. Here Prof. Schapera has chosen deliberately to confine himself to a more limited field—one, moreover, in which his authority is undisputed. This has enabled him to bring together in a readily accessible and valuable form a rich array of ethnographical material on political organization for the whole area. His emphasis on the importance of historical factors, which arises directly from his wide knowledge of the literature of the region, provides a valuable corrective to the more purely structural analyses of tribal government.

But "Government and Politics in Tribal Societies" is not a mere compilation ; it is an essay in the comparative method. Initially, in outlining his own mode of approach, the writer argues that the concept of the 'political community' justifies him in treating as like units the Bergdama band and the Sotho 'nation', despite their great difference in size, territorial extent, social composition and complexity of organization. Thus by contrasting Bushman hunters and collectors with Bantu pastoralists he is able to deduce some of the 'apparent trends' in tribal government. For example, as one moves from one extreme of the continuum to the other, the community tends to become much larger and more heterogeneous ; the functions of the government become more numerous and varied, and specifically 'political' institutions develop. This in turn is associated with greater specialization, and the emergence of a hierarchy of authorities, often on a regional basis, and so on. These conclusions are valuable and interesting in themselves,

but they also point out some of the limitations of the method Prof. Schapera has followed in the present volume. Since the conclusions that emerge from his comparison are couched in terms of a theory of 'development', it would seem that the units of comparison do not in fact belong to the same order of social organization. Prof. Schapera indicates the areas of social life into which one must inquire in studying political organization. It is to be hoped that he will follow this up with a comparative study of the Southern Bantu alone, to whom the bulk of the material presented is in fact devoted, where one is dealing with units of the same order of social organization.

A. L. EPSTEIN

TRAVELS IN SOUTH AMERICA

Highway of the Sun

By Victor W. von Hagen. Pp. 264+21 plates. (London: Victor Gollancz, Ltd., 1956.) 18*s*. net.

Tupari

By Dr. Franz Caspar. (Translated by Eric Northcott.) Pp. viii+224+16 plates. (London: G. Bell and Sons, Ltd., 1956.) 18*s*. 6*d*. net.

THESE two books have one characteristic in common, namely, that both are popular accounts of their authors' travels in South America, but that they do not set out to describe any scientific discoveries their expeditions may have made.

Mr. von Hagen's object was to follow and record the Inca roads in Peru. The general lines of the road system were already known, but the expedition has doubtless filled in details, verified the physical remains of the roads and plotted them on maps. They tested the pace of local relay runners at an altitude of about 14,000 ft., finding that it would have been possible, as the chroniclers said, to cover the distance from Cuzco to Quito in twenty-four hours, and this is perhaps the most interesting piece of information in the book. For part of the journey on the coast there were archæologists in the party, but their chief concern was not with the roads and their results are for publication elsewhere. Had they been consulted they could have saved the author from publishing a picture of a tapestry of much later date as a mummy wrapping from Paracas Cavernas (p. 192), and a double whistling jar of Coast Inca type as Mochica, which is much older (p. 224).

No one will claim that travel off the beaten track in Peru is comfortable, and the discomforts and dangers of the journey lose nothing in the telling. The expedition had one eye on the *New York Times*, to which it sent frequent cables, and the style in which the book is written is sufficiently indicated by the sub-title, which describes the roads as "fabulous high-roads".

Dr. Caspar, who was returning from Bolivia to Europe, wished to visit and study some forest Indians who had not been changed by acculturation. He succeeded in joining a small group of about two hundred people in the Brazilian forests, who called themselves Tupari, although they turned out to be an agglomeration of the remnants of various tribes. He lived among them for about six months, gained their confidence, worked and hunted with them, and took part in some of their ceremonies; in fact, he seems to have done almost everything except respond to the advances of the wife they offered to him. The story is told in a straightforward and interesting manner, and it gives a good general idea of the way the Indians lived. It mentions some of the clues which the author obtained about their beliefs. The book does not give any details about how they built their houses or made their pots, the material of their arrowheads, the form of their stone tools or the exact nature of their musical instruments. There is no map, apart from a sketch map of a small area which serves no useful purpose, and there is no index. The author made extensive ethnological collections and could doubtless publish details about them elsewhere, but so far as I am aware he has done little in this way.

There is a sad postscript describing briefly a subsequent visit six years later, in 1955. Two-thirds of the group had died of measles, caught from rubber gatherers. The remainder had adopted European dress, and fallen, as the author says, victims to civilization.

G. H. S. BUSHNELL

TRANSMISSION-LINE THEORY

Transmission-Line Theory

By Prof. Ronald W. P. King. Pp. xii+509. (London: McGraw-Hill Publishing Company, Ltd., 1955.) 90*s*.

THIS book gives what is probably the most comprehensive treatment of the radio-frequency transmission line which has been published. The basic theoretical treatment is applicable to all frequencies, of course, but effects which are negligible except at high radio-frequencies are dealt with at length.

The first chapter deals with the infinitely long line by both the distributed-circuit and the electromagnetic-field methods and discusses thoroughly the limitations of the former. Parallel-wire lines (two, three or four wires, screened or unscreened), coaxial lines and strip lines are all discussed.

The terminated line is then treated, including the conducting pistons and disks used as terminations at very high frequencies. A consideration of the impedance and admittance of lines follows, including stub and other methods of modifying impedances, balanced to unbalanced transformations and hybrid junctions. Matrix methods of solution are used here. It seems a pity that anyone, having thought out an elegant arrangement for dealing with balanced to unbalanced lines (p. 207), should call it an 'unbalance squelcher', but for this Prof. King cannot be held responsible.

The distribution of current and voltage along a line, the measurement of standing-wave ratio and Q-factor from the current distribution, are topics which are thoroughly discussed. Many different forms of discontinuity are treated.

This book would overwhelm any reader who was just commencing the study of lines, because the author insists on a rigorous treatment, without introducing approximations until a late stage in the discussion. It should, however, prove a useful and stimulating book for any reader who has already a fairly good knowledge of the subject, and it will also be very useful to the radio engineer who needs the theoretical treatment of some specific line problem such as, for example, the effect of a bend in a parallel-wire line.

The book is well produced, the mathematics being well set out and the numerous graphs and diagrams adequate in size. Rationalized M.K.S. units are used.

C. R. STONER

NATURAL GAS IN SCOTLAND

By T. S. RICKETTS and D. C. ELGIN
Chief Engineer Technical Officer
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NATURAL gas is now being used for town gas supply in the Midlothian town of Musselburgh and at several smaller places nearby, including Cockenzie, Port Seton, Prestonpans and Tranent. This is the first example in Great Britain of natural gas being distributed for use as a commercial fuel.

The natural gas occurs in an anticline centred on a crest of agricultural land about 550 ft. above sea-level close to the small village of Cousland; Cousland is approximately four miles south-east of Musselburgh and three miles east of Dalkeith. The existence of the anticline was discovered by the former D'Arcy Exploration Co., Ltd. (now known as B.P. Exploration Company, Ltd.), in 1938, and most of the present knowledge of its extent and character has been obtained from two major boreholes, one sunk in the immediate pre-War period as part of an oil exploration, and the other sunk in 1954 as part of the nation-wide search for natural gas sponsored by the Gas Council. The anticline is thought to run in an east–west direction and the natural gas occurs in porous calciferous sandstone series at two main levels, 1,582–1,632 ft. and 1,720–1,735 ft. (depths measured at the site of the original deep bore). Smaller shows of gas have been discovered in deeper strata, for example, at 1,760–1,806 ft., and very small traces of oil have been detected in several of the oil-shale strata located by the drillings.

The calciferous sandstone in which the gas is trapped has an average porosity of 15 per cent; it occurs in the form of a dome which is sealed by water at a depth of about 1,700 ft. The mean diameter of the gas-bearing sandstones above water-level is estimated to be about 2,500 ft.; the pores in the gas-bearing sandstone above water-level contain, on the average, about 40 per cent of moisture and about 60 per cent of gas. The sandstone is covered by a continuous upper layer of impervious rock which has prevented the natural gas from escaping from the anticline by diffusion upwards and has thus preserved the deposit. The gas is contained in the sandstone layers at a pressure of 620 lb./sq. in. (gauge pressure). Although tests were carried out to ascertain the potential gas production-rates from the sandstone strata at various levels, it was found that only those series at levels higher than 1,700 ft. could yield gas without giving rise to difficulties due to water production. The productive well at Cousland is therefore blocked by a cement plug at 1,663 ft. and the concrete lining is pierced at levels corresponding to the sandstone strata at 1,582–1,632 ft.; the piercing was carried out by means of shaped explosive charges which, under the conditions prevailing at Cousland, give a more positive and controlled connexion between the productive strata and the well than could have been obtained using copper shot.

The gas reserves which are now in communication with the productive well at Cousland have been subjected to gas production tests at rates up to the equivalent of four million cubic feet a day. During these tests the 'draw' of gas from the strata at high offtake rates resulted in the reduction of well-bottom pressures down to 415 lb./sq. in. It is of great interest, however, that at the conclusion of the test runs at high rates of flow, the gas pressure within the well returned to within 20 lb./sq. in. of the normal standing pressure over a period of ten minutes following discontinuation of gas production; the final standing pressure was regained within one hour.

Although this rapid and invariable recovery of gas pressure supports the belief that substantial quantities of natural gas may be trapped within the sandstone strata which are in communication with the Cousland anticline, it has not yet been found possible to obtain an accurate estimate of the total magnitude of the gas reserve. The disturbed nature of the geological structure and the conflicting local evidence have made it difficult to arrive at a firm figure, and estimates have varied from 200 million to 3,000 million cubic feet of gas. It is now believed generally, however, that at least 1,000 million cubic feet are likely to be available from the borehole which is now in operation. The gas obtained from this borehole has a calorific value of between 930 and 960 British Thermal Units per cubic foot. It is principally methane, but in addition to about 90 per cent of this gas there are small quantities of other paraffinic hydrocarbon gases, in particular, about 3 per cent of ethane and about 1 per cent of propane; the remaining 6 per cent is mainly nitrogen with small traces of other inert gases. The natural gas is entirely free of sulphur.

In view of the great importance placed at national level on saving coal by utilizing every other possible indigenous source of fuel, the Scottish Gas Board worked out a scheme for utilizing the Cousland natural gas reserve, and this scheme was brought into full operation when Sir Harold Smith, chairman of the Gas Council, opened the principal valve on the Cousland well-head on October 28.

The well which was thus brought into production comprises a tubular steel outer casing with an outside diameter of 8¾ in. The casing surrounds a 2-in. diameter central tube which acts as the main gas uptake. The annular space between the central tube and the casing extends down to the bottom of the well and the static gas pressure within it reflects pressure conditions in the lower gas-bearing strata. In order to give full and precise control of the well, the 2-in. diameter central pipe is fitted with an arrangement of valves known, in accordance with oil-field practice, as a 'Christmas tree'. The 'Christmas tree' is surmounted by a pressure gauge which enables a careful watch to be kept on well-head conditions. There are two main branches from the 2-in. diameter central tube at the well-head, each controlled by an independent valve. One of these branches, known as the 'burning line', is of a temporary nature and is used for carrying out special production tests on the well; the gas produced during such trials is burned in the form of a flare. The other branch is the main gas supply line. This conveys gas at well-head pressure to a cylindrical water-separator

designed to remove mist or droplets which might be evolved under abnormal conditions. The gas line then enters a small building housing a series of three pressure regulators which enable the pressure of the gas to be reduced in three convenient stages, from more than 600 lb./sq. in. to about 3 lb./sq. in. This fairly rapid reduction in gas pressure is accompanied by sudden cooling of the gas, and the staging of the pressure reduction through the three regulators has to be balanced very carefully to avoid blockage of the system by the separation of frozen solids from the gas stream; these solids may be in the form of ice due to the freezing of condensed water vapour, or methane hydrates, the latter being crystalline solids formed by the loose combination of methane and water vapour at low temperatures. In order to prevent formation of these solids, the governor system is to be wrapped with a special electrical resistance heater in the form of flexible tapes, enabling the temperature of the gas to be maintained at a safe level despite rapid reduction of pressure.

As the natural gas does not have a characteristic odour, arrangements have been made for small quantities of a special odorizing agent to be vaporized into the gas before it leaves Cousland. The odorizing agent chosen was tetrahydrothiophene (C_4H_8S), known generally as T.H.T. The level of odorosity is kept within carefully controlled limits, the aim being to achieve a smell resembling, as closely as possible, the characteristic odour of town gas.

The natural gas is conveyed from Cousland to Musselburgh in a 4-in. diameter main which was laid specially for this purpose. At Musselburgh the pressure of the gas is reduced by an orthodox gas governor to a few inches water-gauge and, after being metered, is mixed with coal gas manufactured in standard continuous vertical retorts at Musselburgh gasworks. The calorific value of the coal gas made and the proportion of natural gas added to it are so balanced that the calorific value of the mixture produced is 450 B.Th.U. per cubic foot, which is the declared, or statutory, calorific value for Musselburgh. The calorific values of the natural gas, of the coal gas, and of the mixed gas are measured by special continuous recording instruments, and this enables a very fine control to be kept on the calorific value of the mixture prepared for the local gas consumers. Another type of recorder has also been provided to allow the specific gravity of the gas to be measured, and it is well known that if the relationship–calorific value/square root of specific gravity (known as the Wobbe index) is kept fairly constant, the gas will burn satisfactorily at consumers' appliances.

After mixing the natural gas and the coal gas, the final product is passed to an orthodox water-sealed gasholder for storage prior to distribution as required by consumers. A careful check has been kept on the behaviour of consumers' appliances since natural gas has been included in the town gas supply; as expected, appliance performance has been normal and no special adjustments have been required.

It is estimated that for every 7,000 cubic feet of natural gas used for this purpose, about one ton of high-grade deep-mined coal will be saved. The average quantity of natural gas included daily in the gas supply from Musselburgh is approximately 60,000 cubic feet, which represents about 9·4 per cent by volume of the town gas distributed.

While gas is being removed from the Cousland reserve, the well-head pressure is kept under careful observation. So far, the original reservoir pressure has been maintained. Any diminution in pressure which may occur will be carefully followed up with the view of ascertaining whether the sustained removal of natural gas is having any permanent effect on the reserve pressure. From time to time production tests will be carried out to ascertain whether the quantity of gas removed through the borehole represents a significant reduction in the quantity of gas in the reserve. It is thus hoped to determine, as soon as possible, the total extent of the Cousland gas field. If the field is proved to be a fairly large one, arrangements would be made to utilize the gas on a much larger scale.

Apart from the obvious commercial value of the gas which is being obtained from the Cousland anticline, and the contribution to the national fuel economy which it represents, the Scottish Gas Board is also interested in the structure from quite a different point of view. It is considered that after the pressure in the gas-bearing sandstone has been removed by the use of the greater proportion of the natural gas, the structure can be used as a very large underground gas-holder; this possibility is being examined.

It has been possible at Cousland to harness an extremely old natural resource in a very modern way, and to set in motion a commercial enterprise which is at the same time in the nature of a scientific exploration. The use of the gas reserve there may reveal a great deal of important information about the geological structure of the neighbourhood and lead to further valuable discoveries.

THE TECHNISCHE HOCHSCHULEN OF WESTERN GERMANY

By Dr. J. HORNE
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THIS brief survey of the German Technische Hochschulen (technical high schools) presents a short history of their development and scientific achievements, and concludes with an account of their provisions for broad non-vocational courses under the name of the Studium Generale. It is based upon personal visits over many years, and in particular upon a recent extensive study tour through many of the technical high schools.

The German technical high schools enjoy equal status among themselves and in public esteem despite their considerable differences in student numbers, ranging from 3,164 in the smallest to 5,716 in the largest (summer 1956). More significant and striking is their undoubted parity in standing with the older universities in Germany. Indeed, the latter's initial opposition to the applied sciences was overcome by three main features which have characterized the

whole development of the technical high schools from their early humble origins to the present day. These features may be summed up as follows: (1) The high standard set for entry, equal to that required by the universities, and the inclusion of general subjects in the science and engineering curricula; (2) the technical high schools' reputation for excellent teaching; and (3) their achievements in scientific and technical research.

The schools were able, at a very early stage, to meet the charge that they may well produce competent engineers but not truly educated university men (Akademiker).

The insistence upon a broadly based approach to the studies of scientific disciplines had its roots in the new modern schools (*Realschulen*) which sprang up in Germany during the eighteenth century, in response to the demands of a new experimental and industrial age. These schools offered a challenge to the older type of grammar schools (*Gymnasium*) which until then had been regarded as the only source of a true education and the sole preparation for the universities and a professional career. Now these new schools replaced the classics by more mathematics, physics and chemistry, practical laboratory work, and courses in modern languages. A little later a compromise type, the *Realgymnasium*, developed which retained Latin at the expense of one foreign language. Against widespread prejudice, these new schools soon built up a solid name for themselves by attracting enthusiastic science teachers from the universities and from industry. Moreover, the *Realschulen* took over, unchanged, the whole range of general subjects such as literature, history, music, etc., which were offered at the grammar schools, and the examinations, too, were fixed at the same high level. In this way the modern school ensured the same opportunities for its pupils when entering a university. Since the boys (and later also girls) usually elected to read scientific subjects, their lack of classical languages was no obstacle. Some faculties demanded that they should take a course in Latin during their first year.

Simultaneously with these modern schools, and prompted by the same new outlook in science and industry, there developed the early trade or technical schools in many German cities, notably in Berlin. These served, in the first place, the needs of special skills and industries, but soon expanded to include other 'useful' subjects of commercial and also general nature. These technical schools drew, from industry and the Civil Service in each German State, enthusiastic and progressively minded teachers, and they received generous endowments from civic or noble patrons. Within a short time they were raised in status and changed their names to academies, in tune with their function and importance. This elevation brought about the fixture of a later age at entry (seventeen years) and a higher scale of examination requirements, both for diplomas and trade certificates.

Barely fifty years later, these widely expanded and developed institutions received their foundation charters and became university centres of science and technology—the technical high schools of to-day.

Braunschweig, although an older ducal foundation (1745), shared the same development with the other institutions of its kind, such as Karlsruhe (1825), Munich (1827), Dresden (1828), Stuttgart (1829) and Darmstadt (1836). Aachen, the largest to-day, was the first technical high school to be created as a university directly, in 1870.

The most powerful stimulus in all these foundations was given by the example of two Austrian imperial institutes—the Polytechnic of Prague (1806)* and the Polytechnical Institute of Vienna (1815), which became the Technische Hochschule soon afterwards. The immediate success of the latter, in particular, found ready imitators in the German centres, and this eager emulation explains the very rapid succession of the academies or polytechnics in Germany. The Austrian institutes had been created on the pattern of the famous École Polytechnique of Paris, a former military training college, then the leading school of technology in Europe.

The Austrian polytechnics were from the start distinguished by certain rights and privileges usually granted only to universities: the freedom of teaching and learning, the right to confer degrees, and generous endowments for research and expansion. Prague and Vienna opened with courses leading to high-level engineering diplomas and degrees. The school in Vienna had a very strong influence on the trends in Germany, and Hanover even appointed a professor from Vienna as its first principal, and he took from his own institution the broad teaching aims, "to promote industrial skills by the application of scientifically based instruction". The full extent of this impact can best be gathered from the pattern of the four-year courses in Hanover which in many ways resemble the undergraduate courses in science, especially engineering, at British universities. We can discern a broadly introductory year, while the second, still chiefly devoted to principal subjects, also includes courses in economic geography, management and modern languages, all "being useful to the engineer". The last two years of the course show a gradual approach to higher specialization, markedly in the applied sciences.

The fame and success of the new foundation at Hanover may be gathered from the fact that when it was raised to a technical high school (1879–80), the enrolment of students from Great Britain alone was 2 per cent of the total number, and higher from other countries. Comparable international standing was soon gained by the other German academies or polytechnics, and along with their fame as centres of teaching grew their reputation for their research achievements.

This is particularly true for the first years after their elevation to university rank, and this in turn helped to attract eminent scientists to their staffs. The granting of charters was in all cases merely an outward recognition of those which had, in fact, already become full university centres, working as yet without the academic titles and offices. The scientific contribution of the technical high schools may perhaps be illustrated by a reference to the German share in the Nobel Prizes for physics and chemistry, above all the latter, in which German scientists, among them many professors at technical high schools, gained the greatest numbers of the award (twenty), compared with Britain's eleven (total awards, forty-nine). These figures are the more impressive if we remember that under Hitler scientists were forbidden to accept the Nobel Prize and that the Prize is not awarded for work in applied fields, the

* Some five hundred years earlier, also at Prague and on the pattern of Paris, the first German university had been founded.

very disciplines in which the contribution of technologists in technical high schools (or trained in them) has been outstanding.

During the first chaotic years after the Second World War the schools lost a good deal of ground, but the past five years have seen a remarkable recovery in all fields of research, as the premises and physical conditions permitted the resumption of normal work.

The high standards of work and research led at a very early stage to a close link with local industries. The professors and assistants act as consultants in their special fields, and this close contact with industry has been a direct boon and incentive to the students of each department. The technical high schools have also for years conducted industrial apprentice schemes for vacation work and employment after graduation, and often arrange for engineering students to acquire practical experience for a minimum of six months, before commencing their studies.

The success of the technical high schools, while they were still academies, was so evident and rapid that similar colleges were set up on the same lines, serving higher education in commerce, economics, journalism, etc. Like the technical high schools, these new colleges added whole faculties of humanities which became organic members of the life in a technical high school. These faculties had developed from small departments in the academies and technical schools. In the course of the educational reforms in German universities (1948–51), the faculties of humanities assumed the responsibility for the programmes of the Studium Generale, thus carrying out their original function under a newly revived name.

In the Studium Generale, the faculties of humanities or, as they are sometimes called, of general subjects, offer annually a choice of lecture courses or individual lectures and discussion groups on a wide range of subjects. Artistic and musical activities and pursuits, which in Britain one may expect to find within a guild of undergraduates, are also part of the Studium Generale, and may be subsidized by the special funds set aside by the Ministries of Education for these broader education schemes in universities and technical high schools. Every week or month, a special Dies Academicus is reserved for major lectures on principal university themes. They are usually opened by the Rektor, a dean or a prominent visitor from outside. The discussion groups take up and develop in smaller circles under informal conditions the subjects touched on in the main speeches. The Dies Academicus usually concludes with dramatic or musical performances by the appropriate group, and prizes are given for the best presentations.

One of the most important results of the Studium Generale especially noticeable in the technical high schools is a new and close contact between students and teachers, particularly the younger lecturers. The fact that a selected set of lectures and other events are compulsory for the first year or two years has not appreciably affected the growth of this contact. Both sides greatly enjoy smaller informal gatherings. The gradual creation of more and more residential facilities enhances this development, especially where the warden is an enthusiastic professor or lecturer, as I found in the students' houses at Karlsruhe and the International Students' Village at Aachen, both attached to the technical high schools in those cities. Other forms of residence are large blocks of flats at Munich or Stuttgart. The small students' discussion groups or informal gatherings often take place in the common rooms at late hours. Residence is greatly coveted by all students and the facilities, still rather limited, are divided in equal parts between German and foreign students. Although these students' halls have done much to bring about personal contacts between students and staffs, the old tradition of aloofness has not quite died out. The residents of one hostel complained that their open invitation to Sunday coffee and cake (dinner in hall is not a social focus in German residences) had not been accepted by a single professor or his family ever since the hostel was opened two years before.

On the other hand, the personal concern of the teachers in the technical high schools and their friendship with the rank and file of the students were clearly in evidence everywhere, even, too, where I heard the complaint. In general, students' reactions to the provisions of liberal education in the Studium Generale were extremely favourable and nobody ever criticized the level of the lectures as too high or the element of compulsion.

One grievance voiced in several technical high schools was that there is a tendency to place Studium Generale events in the later afternoons and evenings, mainly 5–7, that is, after a full day's lectures and laboratory hours. This unfavourable time must be chiefly responsible for the small average attendance of 35 per cent, while the Dies Academicus invariably shows more than 75 per cent of the students attending. The considerable number of fully employed students (*Werkstudenten*), however, make up a good proportion of the 35 per cent mentioned above and of any discussion groups, where attendances are very much higher. Where these are held in a residence, they are open also to students from outside, and many *Werkstudenten* come to them.

The Dies Academicus owes its success largely to the fact that all departmental lectures are cancelled on this day. Civic and 'Land' theatres and opera houses have always been in the habit of admitting students at very low charge, and the organizers of the Studium Generale, linking on to this old tradition, encourage and arrange visits and introductory lectures for any events of an artistic nature in the city concerned. Also excursions to nearby centres, galleries or theatre and music festivals are provided under the Studium Generale and subsidized by its special funds.

Modern language courses have always been provided in the technical institutions and are open to all students, and study groups sometimes wish to go abroad with their tutors. The latter, however, are only part-time members of the technical high school staffs and cannot organize such tours as, for example, are held every spring for science students and others at Birmingham. The German students, especially of engineering, make use of every opportunity of visiting countries abroad for practical and language experience, and eagerly enlist for exchange or harvest schemes, etc.

In conclusion, it can be said that the technical high schools in Germany are to-day as active as ever, expanding their premises and programmes and making up successfully for the long eclipse in their history, the years under Hitler and immediately after

the War. They certainly make striking provisions for the non-vocational education of their alumni and are concerned with their students' welfare to an extent formerly unknown.

However much a technical high school may reflect the local special demands of the regional industries, such as the Ruhr industries at Aachen or the chemical firms at the Rhineland schools or at Hanover, the technical high schools have never permitted, it seems, the wider aspects of their educational function to be forgotten. In their programmes of broader education they give prominence to-day to social and civic issues, particularly with reference to the scientist's and engineer's responsibility in society. Despite signs of reactionary students' clubs of the old type re-emerging, it must be said that the forms taken over from British university systems are all steps in the direction of closer personal contact with the students. The relevant features in this respect are to-day comprehensive students' guilds, in place of the old politically orientated corporations; the encouragement of small tutorials and informal discussions; and the gradual creation of residential facilities.

LUBRICATION AND WEAR

TWENTY years ago the Institution of Mechanical Engineers convened, under the chairmanship of the late Dr. H. J. Gough, an international discussion on "Lubrication and Lubricants" at which more than a hundred papers were contributed from leading authorities throughout the world. The Conference itself and its proceedings, published in two volumes in 1937, marked the first serious recognition of lubrication as a field of both practical and theoretical importance. As a result of the great success of these discussions, the Institution—in conjunction with its American sister organization and other bodies—decided to hold a similar conference on lubrication with the emphasis on wear. An organizing committee was set up under Dr. D. Clayton in 1955, and the results of its efforts were shown in the Conference on Lubrication and Wear held in London during October 1–3. More than one hundred papers were again contributed and delegates from sixteen foreign countries ranging—alphabetically—from Australia to Yugoslavia were present. It was a particularly pleasant opportunity to renew acquaintance with American workers in the field and to make contact with the large and representative Russian delegation. Unfortunately some of their papers did not arrive in time for publication, but they were given ample opportunity to describe their work in the discussion periods. Most of the sessions were held in the magnificent circular conference room at Church House and a pastel October sun, sustained throughout the Conference, brought out the grace and dignity of the surrounding buildings. Across the bend in the river the glittering dome of St. Paul's looked no less impressive than it did to Wordsworth.

The Conference proceedings were very much down to earth and were extremely efficiently—if somewhat severely—organized. Each section was preceded by a review of the main papers and there was widespread admiration for the effective way in which this was done.

Hydrodynamic lubrication. Perhaps the most striking impression of the papers covered in this field is the extent to which new work often containing important innovations continues to emerge. Even in the subject of journal bearings where, as Prof. D. G. Christopherson (Imperial College of Science and Technology, London) pointed out in his review article, one would have thought that after seventy years the subject would have been fully explored, the papers at the Conference provided ample evidence that this was not so. Many of the new problems have arisen or become more discernible as a result of the increasing tendency to impose higher speeds and loads on bearings: or if they were hinted at briefly in the discussion in 1937, they have received fuller and more critical analysis. Thus it is now clear that the earlier classical theories of hydrodynamic lubrication are no longer strictly valid, as is shown by some recent studies of cavitation in the hydrodynamic film in the regions of low pressure. To some extent the detailed behaviour may also be complicated by the wettability of the surfaces by the lubricant. For example, it has been found that the friction on a bearing operating in the fully hydrodynamic region may be reduced by 20 per cent by coating the surface with an oleophobic layer. Again, the temperature developed in the oil film has now been explored and it seems, surprisingly, as if the temperature around the circumference is almost uniform. This is often aided by turbulent flow in the film at very high speeds. Thus the bearing may be considered to behave as a 'mixer' containing a heat-source to which a stream of cool oil is being added and from which an equal stream of oil at the mixer temperature is being withdrawn. This provides a useful empirical simplification which facilitates bearing design: here a new feature has emerged since 1937, namely, the use of electronic computers. So far as general design is concerned it is interesting to see the general change in bearing dimensions that have become accepted in high-speed operations. The short axial length of modern bearings is a new development that has many practical advantages. Another development of increasing importance is the use of air as a lubricant in high-speed hydrodynamic bearings.

A serious practical problem dealt with in a review article by B. L. Newkirk of Schenectady is that of journal-bearing instability, such as shaft-whipping and oil-whirl. Here a beneficial modification in the structure of the main moving elements is not always possible and in many cases the troubles may be overcome by some special feature of the bearing design. It is possible that more use might be made in future of the quasi-elastic and damping capacity of the oil film itself. This leads to one of the more important ideas that has emerged in the past twenty years of hydrodynamic studies. Twenty years ago it seemed fairly safe to say that under certain extreme conditions hydrodynamic lubrication was not possible, and that only boundary sliding or even that metal/metal contact must occur. It now seems that the hydrodynamic region extends very much further than was then considered likely. As Prof. H. Blok pointed out in his review paper, this type of 'marginal'

hydrodynamic lubrication is largely due to the elastic deformation occurring at and around the contact regions. This makes it possible for hydrodynamic conditions to be carried over into a region where the lubricant film is extremely thin. Coupled with this new approach is the realization that it is no longer possible to treat the lubricant oil—even when it consists of a relatively pure single constituent—as a simple Newtonian fluid. The viscosity of the lubricant is affected by the temperature, by the rate of shear and by the pressure itself. These changes are not instantaneous, and the effect of pressure, for example, on viscosity and on density involves a relaxation time that may be of importance in high-speed sliding mechanisms. More basic work in this field is required and no doubt will be forthcoming in the near future. It would certainly seem that the next few years are likely to see further applications involving very thin-film 'marginal' hydrodynamic lubrication.

Friction and boundary lubrication. In this session it was apparent that great advances have been made since the discussion in 1937, not only in fundamental ideas but also in experimental techniques. In particular, as Dr. F. P. Bowden pointed out in his review paper on the friction of solids, electron microscopy has made it possible to examine the surface damage produced during sliding in very great detail, and recent experiments by Menter and others have even revealed the molecular array and dislocations present in crystalline solids. Whereas in 1937 there was little detailed understanding of the nature of contact between rubbing surfaces, it is now generally accepted that the real area of contact is usually a very minute fraction of the apparent geometrical area and that it is the detailed behaviour at these regions that determines the overall frictional properties of the solids. There is now a large body of evidence to suggest that the friction of metals is due in large measure to local adhesions. In addition, there may be appreciable ploughing of grooves in one surface by the other, so that there will be an additional ploughing term which must be considered. For unlubricated surfaces this is generally small and the main part of the friction arises from the shearing of the adhering junctions. A similar mechanism holds for non-metals, although in this case the deformation or ploughing term may be more important. This is particularly marked in the presence of surface films which can reduce the adhesion term, so that the work of deforming the surfaces may dominate the frictional behaviour. With elastic materials such as rubber the friction during lubricated sliding is largely due to elastic hysteresis losses in the rubber itself. Indeed, one of the new points that has recently emerged is the more general importance of elastic hysteresis losses in the friction and fatigue of sliding and rolling solids. Perhaps the most surprising feature is the extent to which a relatively simple physical picture can explain the frictional behaviour of solids as diverse as metals, diamond, rubber and wood.

Papers in this session included a number of detailed studies of the formation, deformation and subsequent breaking of the contact regions, their number, size and distribution, the extent of the adhesion at the interface, the effect of tangential displacements before macroscopic sliding occurs and the factors determining the occurrence of intermittent or 'stick-slip' motion. Experiments with large-scale model friction-junctions were described which suggested how wear fragments might be produced during sliding. A new point of considerable interest was raised in a paper dealing with friction at extremely high sliding speeds—up to 2,000 ft./sec. The friction falls to a very low value due to melting of the surface layers by frictional heating. With some metals at very high speeds there is not sufficient time for plastic deformation to be propagated through the asperities. They behave in a brittle fashion and surface disintegration occurs. It would seem that the mechanism of friction and wear may be greatly modified at these extremely high speeds.

Boundary lubrication was not dealt with specifically in 1937 and in the present Conference most of the papers in this section dealt with the frictional behaviour of lamellar solids such as graphite, molybdenum disulphide and boron nitride. The gap was well bridged by Dr. C. B. Davies's review paper. He showed that the primary purpose of a boundary film is to reduce the amount of metallic welding across the sliding interface. To be most effective the film should be a solid of low shear strength and high resistance to penetration: and it should not be readily fluxed away by frictional heating because of melting, desorption, decomposition or oxidation. Fatty acids are most effective because of their ability to form metallic soaps at the surface, but these are melted or desorbed at temperatures above about 200° C. Sodium soaps (or, in special applications, the addition of fillers) may extend the temperature-range, but in general for extreme temperatures other types of lubricant films must be used. The most common are the metal sulphides or chlorides formed by adding to the lubricant small quantities of compounds containing labile sulphur or chlorine. For still more extreme conditions films of lamellar solids are now being used, though here the basic technological difficulty appears to be that of obtaining good bonding to the surface. There is evidence that in some cases the metal oxide film is an important partner in the action of these and other boundary materials.

Bearings, ball bearings, and internal combustion engines. There were forty papers covering a rather wide range of miscellaneous problems on lubrication and wear, and these were dealt with in three sessions. Mr. P. P. Love reviewed papers dealing mainly with bearing materials, and pointed out that for medium-duty purposes no bearing alloy has been developed that is significantly better than the Babbitt metal patented in 1839. However, our understanding of the action of these and similar bearing materials has considerably advanced. Important factors are a relatively low melting point and a relatively low shear strength as well as resistance to corrosion and fatigue. It is also desirable that there should be an intrinsic anti-weld tendency between the bearing and the shaft, and here mutual solubility may play an important part. In recent years new bearing materials have been developed partly as a result of special bearing problems in the field of nuclear energy. Many of these can operate in the absence of liquid lubricants. They include bronzes and other hard materials impregnated with graphite, molybdenum disulphide and polytetrafluoroethylene; and plastics containing a variety of fillers. Surface treatments may be very effective either in the running-in process or even over more extended periods. The most widely discussed were surface treatments involving the use of lamellar solids. There was no paper dealing with the 'Sulf-Inuz' process for which astonishing claims have been made, but an interesting account was given of the action of phosphate coatings, which

apparently function by enabling the high-spots to be removed safely during running in.

In the field of ball and roller bearings it was depressing to note how little fundamental research had been published by the bearing manufacturers themselves. As Mr. L. F. Hall pointed out in his review, most of the work has been carried out by national research organizations and by the larger engineering companies. The detailed behaviour of rolling elements in practice is still the subject of discussion: it is clear that at high speeds and low loads in the presence of oil lubricants they often operate under hydrodynamic conditions. In the presence of greases there is evidence that only a very small quantity adheres to the surface and that the bulk of the grease collects outside the the running parts in a state of complete immobility. This conclusion runs counter to the generally accepted view of grease lubrication. On the other hand there is now a better understanding of the factors involved in low-speed rolling, and for the first time there appears to be a sound analytical and experimental study available of the rolling and slipping of balls under elastic stresses. The mechanism of fatigue failure and pitting is still not fully understood and it seems that there is no single cause to which it can be attributed. Interesting problems arise in the lubrication of ball and roller bearings at very high temperatures in gas turbines. Many of these are concerned with corrosion and fatigue produced by the hot oxidizing atmosphere. It is a pity that no reference was made in this session to the promising results obtained by Cattaneo and his collaborators in the United States; they found that small quantities of sulphur in a reducing atmosphere can provide very effective high-temperature lubrication in the bearings of a running turbine.

Gear lubrication attracted attention from only a small number of contributors working directly with gears or with simulating mechanisms. This is a field in which there is still some difference of opinion as to whether hydrodynamic or boundary conditions prevail. This subject and the mechanisms of scuffing both merit further study.

A parallel session discussed the lubrication of internal combustion engines, the use of additives and other miscellaneous applications. It is now generally agreed that reducing the oil viscosity improves the performance of internal combustion engines, but there is clearly a limit to this. When corrosive wear in an engine is important, it may be markedly reduced by increasing the alkalinity of the oil above a certain critical value. A development that could not have been envisaged in 1937 is the effect of nuclear radiation on lubricants. Apart from the danger of developing radioactivity if the oil contains sulphur additives, there is the general chemical deterioration which occurs. In his review Mr. J. G. Withers observed that although aromatics appear to be more stable to irradiation than other types of lubricants, this is not true of their thermal stability. Consequently, in assessing the viability of a lubricant the effect of both temperature and irradiation must be considered and more work in this field is required. Another contemporary problem is the lubrication of nuclear reactors in which liquid sodium is used as a heat-transfer medium. Surfaces which rub under such a medium often suffer excessive wear or fatigue, and little is known in detail of the way in which this occurs or how it can be overcome.

A novel observation in machining investigations is that an electrical potential which opposes the thermal electromotive force developed during machining can increase the life of a tool two- or three-fold, an effect which is attributed to a suppression of the oxidation process. However, this is very recent work and more detailed study is needed.

Wear. A full day was devoted to a discussion of wear, and almost forty papers were summarized in a comprehensive review by Dr. F. T. Barwell. Here again there are new techniques available which shed considerable light on a number of aspects of wear that were obscure twenty years ago. These methods include oblique or taper sections for examining subsurface damage and metallurgical changes, high-resolution interferometry for studying surface contours, micro-hardness tests for studying work hardening and phase transformations, electron microscopy for examining surface deformation on a fine scale, electron diffraction for studying surface structures and, in particular, radioactive isotopes which provide a beautiful means of studying the transfer and back-transfer processes that occur during wear.

The wear process is, of course, complex and many factors are involved. In some cases it may be purely mechanical, as in cavitation or impact, where failure probably occurs by cracking or by fatigue. It may be largely chemical as in corrosion, or a mixture of abrasive and chemical as in fretting. Probably the most common type of wear is that due to abrasion; the surfaces pluck fragments from one another as a result of strong adhesion at minute local regions of real contact, or hard fragments in one surface scrape or wipe away material from the other. Clearly in both mechanisms surface films can play an enormous part and it is generally true that lubricants are, in fact, used primarily to reduce wear and only secondarily to diminish friction. However, even if the adhesion and abrasion processes are reduced or entirely eliminated, there is another effect due to the continued stressing of subsurface elements during repeated sliding. In some cases this may lead to fatigue and failure even though the surface itself is unworn.

Our understanding of the adhesion and abrasion processes themselves is now much more satisfactory than it was twenty years ago. Radioactive studies show that in some cases the plucked fragments are first oxidized and then wiped away, or they may coalesce and become larger fragments which are fatigued by repeated sliding and then peeled off the surface. Even in the presence of lubricants the basic mechanism is not greatly modified. Unfortunately the gap between such studies and real wear problems is a large and very real one. It consists of three parts. First, in a real machine there are multiple factors which may interact in a manner not foreseen from simple laboratory experiments which can only deal with one or two variables at a time. There appears to be no short-term solution to this. Secondly, there is often a dominant factor in the practical problem which a theoretical study may completely overlook. A typical case is the wear of automobile crankshafts, which is generally caused by metal particles or dirt particles embedded in the bearing material itself. Here the basic frictional properties of the bearing-shaft/lubricant combination are less important than the way in which these alien fragments are trapped and held in the bearing metal. Again, in the lubrication of cutting tools it is often the accessibility of the work to the lubricant that is at least as important

as the intrinsic lubricating properties of the machining fluid. Here it would seem that the main onus lies on the technologist who studies the wear as it occurs in practice. The basic research worker can make a direct contribution to practice only if the practical man can indicate with some precision the main causes of failure. Thirdly, there is the general difficulty of assessing in the laboratory the severity of conditions to which a machine may, in practical operation, be subjected. In the discussion at this session it was pointed out, perhaps with some exaggeration, that in everyday affairs those who handle machinery occasionally behave more like gorillas than human beings: and it is during these simian interludes that the crucial damage is usually caused.

The gap between basic studies and practice is thus a large one which is still unbridged. The basic approach has provided many stimulating ideas, and the men of practical affairs have shown a high level of critical perception. What appears to be needed, apart from further efforts in both fields, is closer co-operation between these groups of workers. The Conference on Lubrication and Wear, which brought together engineers, chemists, physicists and metallurgists, should serve as a valuable guide in this direction. All those involved must be grateful to the organizing committee and to the administrative staff of the Institution of Mechanical Engineers for the vast amount of work and organizational skill that went into making the Conference a success.

D. TABOR

NEWS and VIEWS

Sydney Young (1857–1937)

THE youngest son of a prosperous Liverpool merchant, Sydney Young was born at Farnworth, near Widnes, in Lancashire, a century ago on December 29, 1857. He was educated at the Liverpool Royal Institution, at Owens College, Manchester, where he was a student of Sir Henry Roscoe and of Carl Schorlemmer, and at Strasbourg, where he studied under Rudolf Fittig with his life-long friends, Arthur Smithels and J. B. Cohen. He graduated at the University of London in 1880 and in 1882 became lecturer in chemistry under (Sir) William Ramsay at University College, Bristol. The next five years were the most productive in Young's career, for they witnessed his researches with Ramsay into the vapour pressures of solids and liquids and their thermodynamic relations which have become chemical classics. Their work on the critical constants convinced Young of the need for dealing with exceptionally pure substances. In Germany he had become an expert glass-blower, and with the aid of a most efficient 'bubbling still-head' he studied the nature of the lower-boiling fractions of American petroleum. In 1887 he succeeded Ramsay in the chair at Bristol, and in 1903 he became professor of chemistry at Trinity College, Dublin, where, however, his administrative and teaching duties seriously interfered with his experimental work. His most important books were "Fractional Distillation" (1903); "Stoichiometry" (1908, 2nd ed. 1918); and "Distillation, Principles and Processes", written in collaboration with six industrial specialists (1922). His scientific honours included fellowship of the Royal Society in 1893, the presidency of the chemistry section of the British Association in 1904, the vice-presidency of the Chemical Society during 1917–20, and the presidency of the Royal Irish Academy during 1921–26. Young retired in 1928 and died in Bristol after a short illness on April 8, 1937, aged seventy-nine.

Controlled Thermonuclear Reactions

IN the House of Commons on December 10, the Prime Minister said that the progress of work on controlled thermonuclear reactions remained as explained by the Paymaster-General on November 11. Promising results had been obtained with the experimental apparatus ZETA at Harwell, but the interpretation of these would take time. One aspect of the collaboration between Great Britain and the United States in research in this field was the adoption of common rules for the classification of information. If the proposals of a joint United States/United Kingdom Committee for the declassification of certain categories of information now under consideration were accepted, it would be possible to make public more details about work now proceeding in both countries.

Availability of Russian Scientific Literature

THE Parliamentary Secretary to the Ministry of Works, as representing the Lord President of the Council, was again questioned on December 10 regarding the translation of Russian scientific and technical literature, and said that many individual scientists with a knowledge of Russian are employed part-time on this work, and a small number, part-time, in Government scientific and technical research establishments. Government departments also use, on a contract basis, panels of translators outside the Government services. It is hoped to improve the availability of English translations of Russian literature. Mr. Nicholls then added a somewhat surprising remark to the effect that the aim should be to encourage more scientists to learn to read Russian. While no doubt a working knowledge of Russian, such as most scientists have of French and German, would be useful, this would not enable them to dispense with the services of specialist translators. Asked about the appointment of a scientist of scientific standing as scientific attaché in Moscow, who in his own right would have access to Russian scientists, thus reducing the delay in making available the latest information about Russian developments, Mr. Nicholls questioned whether any such appointment from Britain would be welcome without voluntary co-operation in the U.S.S.R. Earlier, Mr. Nicholls had stated that the appointment of a scientific attaché in Moscow is again being considered, and that he recognized the importance and urgency of the matter; he added that it is not quite correct to say that the Russians have a scientific attaché in Britain.

International Palæontological Union

The International Palæontological Union has hitherto functioned as a department of the International Geological Congresses, but at the 1956 Congress in Mexico it was decided to extend its activities, and it is now proposed to publish a directory to the palæontologists of the world. The expanding interests of the Union have necessitated arranging a meeting previous to the next Geological Congress, planned for 1960 in Copenhagen, and the president of the Union (Dr. Maldonado-Koerdell, Mexico City) has decided to call a meeting to coincide with the fifteenth International Congress of Zoology, and the preceding Colloquium on Zoological Nomenclature, to be held in London during July 9–23, 1958. During this session the Union will discuss and adopt a revised constitution, as modified from that first put forward in 1956 at Mexico. All interested palæontologists should write to the secretary for further particulars: Dr. Jean Roger, Service d'Information géologique, B.R.G.G.M., 74 rue de la Fédération, Paris XVe.

Physics in American Schools

The American Institute of Physics, in collaboration with the American Association of Physics Teachers and the American Physical Society, with the support of the Fund for the Advancement of Education and the National Science Foundation, is embarking on a programme to help improve the quality and quantity of physics taught in American high schools and colleges. This educational plan, which has important implications for the teaching of science in America, has the following objectives: (1) to make a basic course of physics obligatory for every secondary school student; (2) to encourage young qualified people to seek careers in physics; (3) to investigate the possibility of teaching physics to large numbers of students by the use of television and colour films in spite of the great shortage of science teachers; (4) to assess the increasing need for physicists in a technological society and to strengthen physics instruction in high schools and colleges for those not specializing in science. To assist with this work, the American Institute of Physics has added to its staff two visiting professors, namely, Prof. G. O. Gale, on leave from the Physics Department of Grinnell College, Iowa, who is working on the use of television and films in education, and Prof. W. C. Kelly, on leave from the Physics Department of the University of Pittsburgh, who administers a scheme whereby distinguished physicists visit colleges other than their own as guest lecturers.

Journal of Ultra-structure Research

The *Journal of Ultra-Structure Research* has been introduced as a medium for the publication of work dealing with the organization of biological materials as analysed by means of the electron microscope, X-ray diffraction techniques, X-ray microscopy and polarization, optical and infra-red analyses, etc. Papers dealing with techniques and instruments which are of importance in this field are also accepted. The field covered by the *Journal* extends from the structure of molecules of biological interest to the level of cell and tissue organization at the limit of the range of the optical microscope. Its editors are Fritiof S. Sjöstrand (editor-in-chief) and Arne Engström of Stockholm, but in accordance with the present practice of international journals it has a number of eminent scientists on its editorial board, and papers are accepted in French, German or English. This should ensure a high standard of published work. The first issue of the *Journal* contains two articles in French and five in English, describing work with a preponderance of electron microscope studies. Each paper has a summary in the language of the main article: probably such summaries would be of greater value if they were given in three languages. The title *Ultra-Structure Research* is adequate provided one is aware that the problems discussed are biological, but it is a question whether a title indicating the biological character of the papers might not have been an advantage. The editorial office, to which manuscripts should be sent, is in the Department of Anatomy, Karolinska Institute, Stockholm 60, Sweden. The *Journal* (subscription rate for the first volume of four issues is 15 dollars, current first issue, November 1957) is published by the Academic Press, Inc., 111 Fifth Avenue, New York, 3.

Bernice P. Bishop Museum, Honolulu

Annual reports of museums are increasingly departing from the formal types of even a decade ago, and the title "No Ivory Tower" is that adopted by the Bernice P. Bishop Museum for its annual statement for 1956 (Honolulu: Bernice P. Bishop Museum, 1957). An attractive cover in bold colour introduces a report written in a lively and entertaining style. The title emphasizes the present position of museums, for if an ivory tower implies an institution isolated from the community, then Bishop Museum is the direct negation of such an edifice. The very existence of this and other museums depends not on divorcing themselves from the life of our time, but on effective participation in community and world affairs. The goal of the Bishop Museum is to make a continuous contribution to knowledge by its studies of man and Nature in the fields of science and history. The whole report amplifies this basic idea in the realms of exhibition, guide service, relationship with other educational institutions, research, public relations and reserve collections. An eminently worth-while activity is the circulation to neighbouring centres of cases under the general title of "Museums in Miniature". The report is well illustrated, and soaring attendance figures—doubled since 1952—are a measure of the vitality of this well-known museum.

The Cave of Niah, Borneo

From the prehistorian's point of view there is nearly everything to learn about south-east Asia. Of course, the work of Dubois and of Movius must not be forgotten, nor must that undertaken by the authorities of the Raffles Museum. But even so, our knowledge is woefully slight, especially as regards cave sites. I. Evans collected a few stone tools from a cave, and recently the Sievekings have explored a possibly mesolithic cave site near Penang; but otherwise all is still a blank, particularly so as regards Borneo before the time when the island apparently became a factory for certain types of beads, some of which seem to have reached even the shores of eastern Africa. The illustrated article by Tom Harrisson which appears in *Man* of November 1957 will therefore be very welcome. The site, some 800 ft. wide and 200 ft. high, is truly magnificent. But it was only on excavation that industries were discovered. These seem to be of two sorts, those norm-

ally found in habitation sites and those occurring in cemeteries. Flaked stone tools and polished axes have been unearthed as well as pottery. According to carbon-14 dating, it would seem that the earlier levels must go back in time into the palæolithic period. But this method of dating is only reliable when all the relevant factors are known. As we are dealing with a new region, it might be wiser to wait until a number of levels at various sites have been tested. Tom Harrisson's explorations will doubtless be continued, and it is probable that very important discoveries will be made.

Cleansing of Oil-polluted Birds

THE Royal Society for the Prevention of Cruelty to Animals has published a most useful pamphlet to help those who wish to help in the cleansing of oil-polluted birds. Whereas, for several decades, many thousands of birds yearly have been victims to oil-polluted sea water, the oiled swan is a more recent problem. Fortunately, this is a problem which appears to be much more readily soluble than that of the oil-polluted sea-bird. The principal and most harmful primary effects of oiling-up are heat loss due to loss of the heat-retaining air 'jacket' normally enmeshed in the swan's feathers. The pamphlet shows that products with strong irritant solvents like paraffin oil are lethal to birds and must never be used. Correct methods for catching and degreasing are described, as is the way in which the bird can be quickly and humanely killed when the pollution is too severe for recovery. The information in this pamphlet should be widely known. It may be obtained from the R.S.P.C.A., 105 Jermyn Street, London, S.W.1. Price 6*d*.

Leaf Shape, Nutrition and Temperature

E. NJOKU has described experiments in which plants of *Ipomoea* were grown at high night temperature and at higher nutrient-levels, with observation of leaf shape and rate of formation (*New Phytol.*, **56**, 154; 1957). On a node-by-node comparison, the treated plants yielded less deeply lobed leaves than did the controls. Of the three mineral elements tested, nitrogen had the greatest main effect, while phosphorus and potassium had smaller but significant effects. The potassium–phosphorus interaction was unique in increasing rather than decreasing leaf lobing. In all the experiments, changes in leaf shape were highly correlated negatively with changes in the rate of leaf production ($r = -0{\cdot}994$). It is suggested that the effects of high night temperature and mineral nutrition on leaf shape are exerted through their effects on the rate of leaf production. The results are discussed with reference to theories which have been put forward to explain heteroblastic development.

Geochemical Prospecting for Ores

IN recent years much attention has been given to the development of geochemical methods of prospecting for mineral deposits, since in country covered by surface detritus these techniques sometimes provide a means of discovering ore occurrences that are otherwise masked from view. Although the literature on this topic is extensive, text-books (other than in Russian) have hitherto been lacking. This need has now been met by a publication entitled "The Principles of Geochemical Prospecting" (Bull. U.S. Geol. Surv., 1957. No. 1000-*F*. Pp. 130. 40 cents), in which Dr. H. E. Hawkes summarizes the results and conclusions of world-wide researches conducted up to March 1954. Geochemical prospecting most commonly comprises the systematic chemical analysis of rock, soil, gossan, glacial drift, vegetation and water, with the view of discovering an 'anomaly' which reflects the presence of ore; and it is rapidly becoming essential for the economic geologist to have an understanding of the principles governing the evolution and distribution of such anomalies. Students will find that Dr. Hawkes's text deals with the fundamental concepts of this subject in a clear and comprehensive manner, with the bare minimum of technical jargon. A companion work is "Geochemical Abstracts" (Bull. U.S. Geol. Surv., 1953–7. No. 1000 *A* and *G*), of which the first part (151 abstracts) covers the period to June 1952 and the second (117 abstracts) from June 1952 to December 1954. It seems likely that this compilation will develop into an annual publication.

Zoological Nomenclature

THE International Commission on Zoological Nomenclature gives notice that, as from June 30, 1958, it will start voting on the following cases involving the possible use of its plenary powers for the purpose specified against each entry. Full details of these cases will be published on December 30 in the *Bulletin of Zoological Nomenclature* (**13**, Double-Part 10/11, and **16**, Part 1): (1) *Selene* Lacépède, 1803; *rostrata* Lesueur, 1817 (*Muraena*); *latipinna* Lesueur, 1821 (*Mollienesia*); *fuscus* Storer, 1839 (*Syngnathus*): establishment of precedence of, over other names published in the same work and on the same date (Cl. Pisces); (2) *Monograptus fimbriatus* var. *similis* Elles (G. L.) and Wood (E. M. R.), 1913; *Monograptus triangulatus* var. *major* Elles and Wood, 1913; *Monograptus communis* var. *rostratus* Elles and Wood, 1913: designation of lectotypes for (Cl. Graptolithina); (3) *Calandra* (*Calendra*) Clairville and Schellenberg, 1798, suppression of, in favour of *Sphenophorus* and *Sitophilus*, both of Schoenherr, 1838, respectively, in interests of universality of nomenclature; *abbreviatus* Fabricius, 1787 (*Curculio*) and *oryzae*, emendation to of *oryza* Linnæus, 1763 (*Curculio*), validation of (Cl. Insecta, Order Coleoptera). Comments should be sent as soon as possible in duplicate to Francis Hemming, Secretary to the Commission, 28 Park Village East, Regent's Park, London, N.W.1.

Whitworth Foundation Awards

THE following Whitworth Foundation Awards for engineers are to be offered for competition in 1958: (*a*) Whitworth Fellowships, not exceeding three in number, normally tenable for two years, and valued at £500 a year, which may be supplemented by dependants' allowances and allowances for travelling; (*b*) up to six prizes of £50 each to unsuccessful competitors whose work deserves recognition, to be spent on furthering the competitors' engineering education. Candidates must be British and have either an engineering qualification of university degree standard, or a Higher National Diploma or Higher National Certificate in Engineering with at least two distinctions. In exceptional circumstances, a candidate may be in the final year of study leading to one of these qualifications. Each candidate must also have

had practical training in engineering totalling 104 weeks. Candidates will be required to write a thesis of 2,000–4,000 words on a subject approved by the Ministry of Education and may be required to sit for a short examination on the basic principles of engineering and to appear for an interview before an examining body. Further details can be obtained from the Ministry of Education.

Oversea Service Division, Colonial Office

THE following appointments have recently been made in the Oversea Service Division, Colonial Office: J. Bowden (assistant director of agriculture (research), Ghana), senior entomologist, Uganda; C. E. Johnson (assistant director of agriculture, Northern Rhodesia), deputy director of agriculture, Northern Rhodesia; A. G. K. Will (field officer, agriculture, Uganda), senior field officer, agriculture, Uganda; R. W. Aleong (assistant government chemist, Trinidad), deputy government chemist, Trinidad; E. G. N. Greaves (government chemist, Trinidad), chemist, Medical Department, Hong Kong; A. E. Kerr (deputy government chemist, Trinidad), government chemist, Trinidad; L. A. M. Lloyd (chief instructor, Kingston Technical School, Jamaica), vice-principal, Kingston Technical School, Jamaica; R. W. J. Keay (research officer, Federation of Nigeria), principal research officer, Department of Forest Research, Federation of Nigeria; W. E. M. Logan (deputy chief conservator of forests, Uganda), chief conservator of forests, Uganda; J. A. Channon (meteorologist, East African Meteorological Department), senior meteorologist, East African Meteorological Department; J. E. Richardson (assistant superintendent of Crown Lands and Surveys, Hong Kong), superintendent of Crown Lands and Surveys, Hong Kong; J. R. Knowles (senior veterinary officer, Northern Nigeria), principal veterinary officer, Northern Nigeria; B. E. B. Fagg (surveyor of antiquities, Federation of Nigeria), director, Department of Antiquities, Federation of Nigeria; W. G. Addison, agricultural officer, Western Nigeria; R. F. Allbrook, soil survey officer, Western Nigeria; K. C. Baxter, agricultural engineer, Northern Nigeria; D. B. Roberts, irrigation engineer, Agricultural Department, Northern Nigeria; J. C. M. Trail, livestock improvement officer, Uganda; R. Webster, soil chemist, Northern Rhodesia; W. D. Carslake, assistant conservator of forests, Sierra Leone; E. W. Chapman, assistant conservator of forests, Kenya; J. M. MacKenzie, assistant conservator of forests, Somaliland; T. S. Wormald, assistant conservator of forests, Kenya; F. J. Matheson, geologist, Kenya.

The Night Sky in January

FULL moon occurs on Jan. 5d. 20h. 09m. U.T., and new moon on Jan. 19d. 22h. 08m. The following conjunctions with the Moon take place: Jan. 13d. 05m., Jupiter 2° N.; Jan. 16d. 15m., Mars 3° S.; Jan. 16d. 23h., Saturn 2° S. In addition to these conjunctions with the Moon, Mars is in conjunction with Antares on Jan. 4d. 05h., Mars being 4·7° N., and Mars with Saturn on Jan. 23d. 10h., Mars being 1·5° S. Mercury is a morning star, rising rather more than an hour before the Sun, but conditions for observation are unfavourable. Venus is a brilliant object low in the south-west after sunset; it sets at 19h. 05m. and 18h. 55m. on January 1 and 15, respectively. Its stellar magnitude is about −4; the visible portion of the apparent disk is 0·192 on January 1 and 0·067 on January 15. Venus is too close to the Sun for observation at the end of the month, inferior conjunction being on January 28. Mars rises at 5h. 35m. at the beginning of the month and at 5h. 20m. on January 31; it is visible in the south-east before sunrise. Jupiter rises at 1h. 55m., 1h. 10m. and 0h. 15m. on January 1, 15 and 31 respectively; it is east of Spica. The stellar magnitude of Jupiter is −1·5, its distance from the Earth on January 15 being 510 million miles. Saturn rises at 6h. 30m., 5h. 45m. and 4h. 50m. at the beginning, middle and end of the month, respectively; it is near θ Ophiuchi, and may be visible low in the south-east before sunrise. It has a stellar magnitude of +0·8 and a distance of 1,010 million miles from the Earth on January 15. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich; Jan. 7d. 22h. 32·6m., χ Cnc. (*R*); Jan. 10d. 06h. 45·1 m., 69 Leo. (*R*); Jan. 30d. 22h. 45·5 m., 97 Tau. (*D*). *R* and *D* refer to reappearance and disappearance, respectively. The Quadrantid meteors are active on January 3, but conditions are unfavourable. The Earth is at Perihelion on January 3, its distance from the Sun being 91·4 million miles.

Announcements

THE Kalinga Prize for the popularization of science, offered annually by the United Nations Educational, Scientific and Cultural Organization, has been awarded for 1957 to Earl Russell (Bertrand Russell).

A SYMPOSIUM on "The Chemistry of Plastics" will be held on February 14 and 15 at the Bradford Institute of Technology, Great Horton Road, Bradford 1. Further information can be obtained from Dr. W. R. Moore, Chemistry Department, Technical College, Bradford.

A GENERAL meeting of the Association of Applied Biologists will be held in the Large Chemistry Lecture Theatre, Imperial College, Imperial Institute Road, South Kensington, London, S.W.7, on January 10. After the formal business of the meeting, there will be a symposium on "The Use of Insecticides for the Control of Virus Diseases". Further information can be obtained from Dr. L. Broadbent, Rothamsted Experimental Station, Harpenden, Herts.

THE Medical Research Council Tropical Metabolism Research Unit, University College of the West Indies, Mona, St. Andrew, Jamaica, has a limited stock of dried lanterns from fireflies (*Photinus pallens*), which may be used for measuring adenosine triphosphate by methods described by McElroy *et al.* (McElroy, W. D., and Strehler, B. L., *Arch. Biochem.*, **22**, 420; 1949. Green, A. A., and McElroy, W. D., *Biochim. Biophys. Acta*, **20**, 170; 1956). The Tropical Metabolism Research Unit will supply them at a price of £2 10*s.* a hundred, which covers the expense of collection and includes air-mail postage, to research workers who apply to the address above.

ERRATA. In the communication entitled "Solution of Mineral Phosphates by Soil Bacteria", by Joan I. Sperber, in *Nature* of November 9, p. 994, par. 3, line 3, for "hydroxyapatite (220 μmgm. P/ml.)" read "hydoxyapatite (220 μgm. P/ml.)"; similarly, in par. 4, lines 4 and 5, in the phrase "1,200 μmgm. lactic acid was sufficient to bring 220 μmgm. phosphorus into solution", the quantities should be 1,200 μgm. and 220 μgm., respectively.

PLANETARY ATMOSPHERES AND CONVECTION IN ROTATING FLUIDS

A SYMPOSIUM on "Planetary Atmospheres and Convection in Rotating Fluids", under the joint auspices of the Royal Meteorological Society and the Royal Astronomical Society, was held in London during May 23–24.

The introductory address was delivered by Sir Harold Jeffreys, who outlined the historical background of the field. He said that two main problems arise, one of them concerned with the large-scale general circulation patterns which can develop in a fluid on a rotating sphere and the other with the onset of convection in fluids. Until the work of Margules (1903) the former problem had been discussed only qualitatively and the theory due to Margules is itself unsatisfactory on account of a wrong boundary condition. Later, Jeffreys (1916) obtained satisfactory agreement in the simplified problem of differential heating of a non-rotating fluid on a plane base and also in the monsoon problem; but the corresponding treatment of the problem of the general circulation of the atmosphere as a type of tidal problem, in which the period becomes infinitely large, produces east winds in all latitudes. This is in direct conflict with the observed fields of mean westerly flow which exist in the upper troposphere in temperate latitudes. Incorporating skin friction into the problem will have the effect of abolishing the relative angular momentum in about ten days in the absence of heat sources. In the general circulation mechanism for the atmosphere, it was pointed out by Jeffreys (1923) that in order to maintain the westerlies in temperate latitudes there must be a transfer of westerly angular momentum from the equatorial regions, which in turn implies a positive correlation between the eastward (u) and northward (v) components of flow and a succession of pressure maxima and minima around a latitude circle. The balance of angular momentum itself can be achieved if the transfer extends to about 10 km. It is thus concluded that cyclones are an integral part of the mechanism of the general circulation.

The second problem concerning the onset of convection began with an experimental paper by Bénard (1900), and the first theoretical paper is due to Rayleigh (1916), who pointed out that the buoyancy forces in a fluid heated from below will be sufficient to overcome the viscous damping forces if a certain non-dimensional number R_a is greater than λ, where λ is a constant of the order of 1,000 and R_a ($= g\alpha\beta h^4/\varkappa\nu$) depends upon the constants of gravitational acceleration, g; coefficients of thermal expansion, α; the excess temperature gradient, β; the depth, h; the thermometric conductivity, $\varkappa$; and ν the kinematic viscosity. The most recent developments in this problem are due to Chandrasekhar (1951 onwards), who has investigated the dependence of λ upon rotation and on magnetic fields. Sir Harold pointed out also the importance of knowing the rotation of the solid body of a planet. If heating takes place at the equator, there must be prevailing westerly winds at great heights, and the motions of spots which may be observed may not tell us the true surface rotation speeds.

Prof. Zdenek Kopal spoke on "The Basic Observational Data on Planetary Atmospheres". Our knowledge of planetary atmospheres, he said, has been derived by both spectroscopic and photometric techniques. The range 3,000–10,000 A. is accessible to optical spectroscopy, and recently radio observations have been made in the 1–20 metre range. Perhaps the most serious difficulty hampering optical spectroscopy is the interference of telluric lines: constituents of the terrestrial atmosphere are relatively hard to detect. The slight shifts due to varying motions of the planets relative to the Earth have to be used for separating the planetary spectrum from the telluric one. Another difficulty is the lack of light from the most distant planets, which restricts us to low dispersions. Observations have been made of the distribution and polarization of the light from the planets as functions of position on the disk and the wave-length used, and the results have to be interpreted by transfer theory, taking into account reflexion at the planetary surface in the case of optically thin atmospheres. The small range of phase angles which can be observed for the outer planets is a major difficulty.

Mercury has a very tenuous atmosphere, not observable spectroscopically, but giving a measurable centre-limb variation of polarization. The mass per unit surface is 0·005 of that above the Earth's surface, but the chemical composition is unknown. Light gases cannot be retained because of the high surface temperature and low surface gravity. Spectra of Venus show the presence of carbon dioxide in considerably greater abundance than in the terrestrial atmosphere. Kuiper has established the variability at different parts of the disk; this is presumably caused by the varying heights of the upper cloud surface. The other atmospheric constituents are unknown; nitrogen is the most probable. The nature of the clouds is unknown: recently the suggestion has been revived that these clouds are water droplets and the lower temperatures now thought to prevail ($-40°$ to $-50°$ C.) could account for the absence of water-vapour lines. Carbon dioxide has been found on Mars in amounts comparable with that on the Earth. No other constituent has been identified; one may speculate that nitrogen is present. Methane and ammonia have been observed in Jupiter and methane in Saturn, Uranus and Neptune. Herzberg also detected the hydrogen molecular quadrupole transitions in Uranus and Neptune.

It seems probable that hydrogen and perhaps helium form the bulk of the atmospheres of the four major planets. There are several striking features which are not clearly understood, such as the recently discovered bursts of radio emission from Venus, the radioactivity localized in the spots of Jupiter, the presence of latitudinal bands not in solid rotation in the Jovian atmosphere, and their absence on Saturn, while the great strength of the methane bands in Uranus and Neptune cannot be explained solely on the basis of low temperatures and must be considered an unsolved problem.

Prof. P. A. Sheppard read a paper on "The General Circulation of the Earth's Atmosphere". In discussing the general circulation of the Earth's atmosphere, it is necessary to consider two different aspects of the motion; first of all the time-averaged mean flow patterns ($\overline{U}$, $\overline{V}$, $\overline{W}$) and the turbulent field (u', v', w'), which is the departure of the motion from its mean. The mean motion ($\overline{U}$, $\overline{V}$, $\overline{W}$) is now well observed up to about 50 mb., the zonal mean motion $\overline{U}$ (measured positive to E.) consisting of easterlies in a zone about $\pm$ 30° of the equator, a weak easterly circulation near the poles and westerlies elsewhere. The mean meridional motion $\overline{V}$ (measured positive to N.) is more difficult to assess since $v'/\overline{V}$ is large and the two most reliable sources are Mintz and Tucker. Mintz determines $\overline{V}$ in the northern hemisphere from the angular momentum budget for an atmospheric ring, assuming that the mean transfer of westerly momentum in the downward direction is zero at and above 700 mb., and $\overline{W} = 0$ at 200 mb., and determines the vertical velocity $\overline{W}$ from the continuity equation. This shows that there should be a direct cell (ascent at southern end) from 5° S. to 30° N. in winter with $\overline{V} \sim 100$ cm./sec., $\overline{W} \sim 0{\cdot}2$ cm./sec., and an indirect cell from 30° N. to 70° N. in which $\overline{V} \sim 50$ cm./sec., $\overline{W} \sim 0{\cdot}1$ cm./sec. These move approximately 10° northwards in the summer season. Tucker's independent investigations using actual wind observations instead of geostrophic winds (Mintz) reveal a similar meridional cell structure, but the cells themselves are a good deal stronger. The longitudinal variation of $\overline{U}$ reveals the interesting feature that the 500-mb. streamlines are quasi-horizontal waves with troughs and wind-speed maxima over the east of continents and over the Middle East; it is a matter of conjecture whether this is influenced most by the presence of mountains or by the land/sea configuration. There is also a longitudinal variation of $\overline{V}$, and it is clear here that there exists a standing-wave pattern at 50°–55° N., for example, in the winter $\overline{V}$ is positive from 160° to 120° W., negative from 120° to 50° W. and positive again from 50° W. to 20° E.

Prof. Sheppard also pointed out the existence of an upper-air monsoon type of flow over Aden. The total kinetic energy of the atmosphere plotted against latitude reveals a pronounced maximum at about 30° N. and the kinetic energy of the turbulent motion gives a similar type of curve, the ratio of these two quantities in most latitudes being approximately $\frac{1}{2}$ to $\frac{1}{4}$. The question of how much energy resides in different wave-lengths and how this energy is transferred is still difficult to answer, since systematized information is very scanty. Henry and Hiss have attempted to do this using geostrophic winds for January 1951, but the direction of energy conversion is not clear; it would appear, however, that the greater part of the energy resides in the lower wave numbers.

In the concluding address of the first morning session, [the late] Prof. H. U. Sverdrup discussed "The Circulation of the Oceans". He pointed out that, with a few minor exceptions, the currents of the upper layers of the oceans appear to be maintained by the stress which the prevailing winds exert on the sea surface. Qualitative agreement has been obtained between the ocean currents as computed from the observed distribution of mass and as computed from the wind stress, but the mechanism by which such a current as the Gulf Stream is maintained is not clear. In the case of the equatorial counter-current, which flows in the opposite sense to the mean wind, the direction of flow is consistent, as elsewhere, with the geostrophic equation, the vorticity equation and the vanishing of the horizontal divergence. In the case of the Gulf Stream, however, a westward intensification of currents can be expected if horizontal friction terms are retained in the vorticity equation following Stommel, although Charney's discussion of the same problem, which retains the inertia terms instead of the frictional terms, also leads to an intense current on eastern coasts. An appreciable deep-water circulation is found in the Atlantic Ocean only; this circulation is generally described as a thermal, implying that it is maintained by heat being converted into kinetic energy; but this circulation may also be wind-driven in the sense that the prevailing wind carries upper water to the north across the equator off the coast of South America, so that deep water must flow south. In the northern hemisphere, the ocean currents carry considerable quantities of heat from lower to higher latitudes, particularly south of 30°. This heat is conveyed into the atmosphere by evaporation off the east coasts of the continents. Generally speaking, northward flows give off energy to the atmosphere, while southward flows give energy to the sea. The interaction which exists between the atmosphere and the ocean implies that it will be necessary ultimately to deal with the circulation of the combined system of atmosphere plus ocean.

The first afternoon session opened with a paper by Prof. E. Lorenz on "The Circulation of the Atmospheres of the Outer Planets". The planets Jupiter, Saturn, Uranus and Neptune have in common great distance from the Sun, great size and rapid rotation, by comparison with the Earth. Details observable on Jupiter include alternating dark belts and bright zones, irregularly distributed dark and bright spots which move relative to each other, systematic variations of rotation speed with latitude, particularly the 'equatorial acceleration', and a large semi-permanent marking, the Great Red Spot. Belts and zones have also been observed on Saturn and occasionally on Uranus, and spots have been observed on Saturn.

From the thermal wind approximation, a relation between the vertical wind shear and the horizontal temperature gradient, which applies when the horizontal forces and the vertical forces are each nearly in equilibrium, and from the presence of the equatorial acceleration, it is deduced that Jupiter's visible surface lies far above the surface of any solid core, so that only the upper atmosphere of Jupiter is directly observed.

A planetary atmosphere is a special case of a rotating symmetrically heated fluid. Current studies of such fluids suggest explanations for some of the observed features of Jupiter. Experimental studies indicate that symmetrical flow will not be observed if the Rossby number, the ratio of a typical relative angular velocity to a typical absolute angular velocity, lies below a critical value. The scale of the asymmetrical disturbances decreases as the Rossby number decreases. Theoretical studies indicate that any mathematically possible steady symmetrical flow will be unstable if the Rossby number is subcritical,

and that the wave number of the most rapidly growing disturbance increases as the Rossby number decreases. These results, if applicable to Jupiter's atmosphere, imply that the flow should be asymmetrical and that the disturbances should be smaller than those on the Earth, relative to the planet's radius. The dark and bright spots on Jupiter have the proper size for such disturbances.

Experiments indicate that sharp transition zones, such as jet streams and fronts, will form at subcritical Rossby numbers, but theoretical studies to date show only that they may form. The equatorial acceleration of Jupiter bears a superficial resemblance to the Earth's jet streams. A decision as to whether these features are similar phenomena awaits further theoretical work. No permanent feature resembling the Red Spot has appeared in the experimental studies of symmetrically heated fluids, and it is suggested that the spot is caused by some asymmetry, possibly by a feature of Jupiter's solid core.

Dr. G. B. Tucker presented a paper on "Transfer Processes in Planetary Atmospheres". He discussed in detail the transfer of angular momentum mentioned by Sir Harold Jeffreys in his introductory address, and in addition he considered the transfer of water vapour and energy for the Earth's atmosphere. Each of these quantities shows the same conservative feature of a net input into the atmosphere in low latitudes, and a net output in high latitudes with a transfer from low to high latitudes. The flux of any such quantity α across a latitudinal surface has been split up into two parts by Tucker, an advective flux $\bar{\alpha}\overline{V}$ and an eddy flux $\overline{\alpha' v'}$, where α' and v' denote the departures of α and v (the equator-pole velocity component) from the mean values $\bar{\alpha}$ and $\overline{V}$ respectively.

In the case of the angular momentum flux in the northern hemisphere, Tucker's results, which have been obtained from actual and not geostrophic winds, confirm those of earlier workers in indicating a maximum northward flux of angular momentum at 30° N. at about 200 mb. with little horizontal transfer anywhere below 500 mb. and with the major part of the flux arising from the eddy flux term. The calculations of the mean field of velocity $\overline{V}$ in a meridional plane indicate a direct equatorial cell, although there is uncertainty at present concerning the importance of this cell in the mechanism of angular momentum. An independent assessment has been made by Tucker of the transfer of angular momentum from estimates of surface and mountain torques, and the consistency of results from several sources—Priestley, Starr and White, and Mintz—has been verified. Mention was also made of recent analyses of turbulence spectra, which reveal the importance of eddies on the scale of depressions and anticyclones in the transfer of enthalpy and angular momentum.

Dr. Raymond Hide followed with a paper on "Experiments on Convection in Rotating Fluids". He indicated that two main types of experiment have been performed: those in which a shallow layer of fluid is subject to heating from below or cooling from above (type *A*), and those in which the differential heating is imposed in the horizontal. In the former, as mentioned earlier by Sir Harold Jeffreys, when the adverse density gradient exceeds a certain value a cellular convective type of flow (Bénard cells) is established, the onset of this motion being dependent upon the Rayleigh number R_a exceeding a constant λ. The constant is of order 1,000 in the case of zero rotation, but increases monotonically with rotation Ω of the system, λ depending upon the Taylor number $T_a = 4\Omega^2 h^4/\nu^2$. The most recent theoretical results in this case, due to Chandrasekhar, have been verified experimentally by Nakagawa; the most interesting result of the experiments is that the cells become increasingly elongated with increasing rotation. In the type *B*, or dishpan type of experiment, the principal experimental work is due to Fultz and Hide, both of whom considered thermal convection in a rotating liquid with a free surface and subject to horizontal differences of temperature. Hide has shown that there are three régimes of flow depending essentially upon the value of one parameter:

$$\Theta = 2gh\,(\rho_b - \rho_a)/\Omega^2(b-a)^2\,\rho_{\text{mean}}$$

where b and a are the outer and inner radii of the cylinders bounding the liquid and ρ is the density. When Θ exceeds about 1·6, the flow consists of a meridional circulation in which the motion of the liquid on the free upper surface is in the form of inward moving spirals. If Θ is somewhat less than 1·6, the flow is characterized by a regular quasi-horizontal wave-like pattern of wave number m. The motion is almost entirely restricted to a narrow meandering 'jet stream'. The wave train drifts steadily in the same sense as that of the flow in the top surface jet while m depends on Θ. When Θ is reduced steadily from 1·6, m increases slowly until that value of m is reached for which the amplitude of the wave is equal to 0·67 of the wave-length. When Θ has less than this value, unsteady wave flow (vacillation) occurs in which the wave pattern swings about a mean horizontal radius as the whole pattern rotates. A. R. Smith is at present examining the effect of changing ν and $\varkappa$, and his results indicate there is some dependence of the flow characteristics upon the Prandtl number $\nu/\varkappa$. Fultz has made studies of the three-dimensional structure of the flow patterns and has measured the heat flow during vacillation, showing that there is a fluctuation with an amplitude of about 10 per cent of the average value.

Prof. M. J. Lighthill next discussed with much clarity and considerable verve the general theoretical aspects of the problems raised by the speakers who had preceded him.

The first question raised concerned the concept of diffusion. Quantities normally diffuse down their gradients, but several examples had been cited in the symposium in which the direction of the diffusion appears to be up the gradient, or in which diffusion appears to be practically absent although the system is of a type for which experience of other fields of physics would lead us to expect large diffusions. Why is it that the Gulf Stream remains no wider than 100 km. over long stretches of the Atlantic, whereas water jets in water will spread with an included angle of 30°? Similarly, why does the atmospheric jet stream maintain a coherence in spite of the obvious presence of turbulent transfer and observed severe turbulence at its boundaries? Again, it would appear that for many planets, particularly the Earth, the angular velocity of the solid planet does not lie in the middle of the range of angular velocity observed at different latitudes in the other parts of the atmosphere but is approximately equal to the equatorial value; it follows that the

lower parts of the atmosphere are constantly exerting a retarding torque on the upper parts, and the problem then arises of how things remain, on the average, stationary. Finally, there is a fourth difficulty of understanding the up-gradient flow of westerly angular momentum in low latitudes.

Dealing with the fourth of these problems, Prof. Lighthill put forward two explanations; the simpler is that this is an apparent difficulty only, since if one chooses a fixed Newtonian system of reference axes, and one accordingly adds to each relative zonal velocity the amount of 470 cos(latitude) m./sec., the change in the frame of reference makes no difference to the mean a.m. flow and with the fixed frame the northward flow of a.m. in low latitudes is now down-gradient for the absolute motion. The third problem of a.m. balance—the balance between the lower and upper atmosphere—can also be looked at in the same way and made consistent. Such an explanation does not require any mean meridional circulations, as has been postulated on different grounds by Starr and White (1953).

The problem why turbulence does not dissipate the Gulf Stream is one where extensive laboratory experiments need to be performed, in which it is necessary to create in the laboratory either a top-surface water jet which is warmer than its surroundings, or the identical problem of a bottom-flowing cold water jet which is cooler than its surroundings. It may be the stable density distribution which is favourable to the jet remaining compact. Finally, from the observation of the non-dissipation of the atmospheric jet stream, it is clear that there are limitations to the action of turbulence in rotating systems with temperature variations; but it is possible that in explaining this enigma some new idea may have to be invoked; the atmospheric jet stream is neither at the top nor the bottom of the atmosphere, and much of the time it is intermediate in temperature between the air on different sides of it. The only hope for clear understanding here, Prof. Lighthill suggests, is for continued laboratory experiments combined with some new kinds of theoretical model aimed at the central object of explaining what are the forces which hold the jet together.

At the third session, on the morning of May 24, Dr. R. M. Goody read a paper on "The Thermal Structure of Mars". Ground temperatures on Mars in summer and winter have been derived by Hess from radiation emission measurements. These agree with what can be expected from insolation and albedo; they show a greater variation with latitude than on the Earth. There are, however, two considerable sources of error in these determinations, due to the opacity of the atmosphere and the fact that the images in the visible and the infra-red do not coincide owing to differential refraction. Recent spectrographic work by Strong and Sinton should eventually eliminate these. The ground pressure is of the order 85 mb., though this is a little uncertain. The vertical temperature distribution depends on the gases present which are radiationally active. Carbon dioxide is the most important such constituent, being considerably more abundant than on the Earth, and it is probably mixed at all levels; it outweighs in its thermal effect the water vapour in the Martian atmosphere. There is no evidence of any direct solar heating, but in the long-wave spectrum of carbon dioxide the narrow but intense 15μ band, with weaker bands near 10μ, will have a dominating influence in establishing the temperature fields and consequent fields of motion. The thermal driving forces arising from carbon dioxide appear to be smaller than the corresponding water vapour forces; but, possibly due to other factors such as small condensation, strong latitudinal contrast and low surface pressure, which act in the opposite direction, the resulting zonal motions on the Earth and Mars appear to be similar.

The overall picture of the atmosphere is of a convective lower layer of height 8·5 km. with a lapse-rate of 3·7° C. per km., and an abrupt change of gradient at this height into a layer where there is radiative equilibrium. Above 135 km., the rate of collision should be so slow that carbon dioxide ceases to be an effective radiator, and consequently we should get here a high-temperature thermosphere. It is possible that there may exist a high-temperature layer between the thermosphere and the ground.

Prof. H. C. Urey presented a paper on "The Escape of Planetary Atmospheres". Two mechanisms are at work, he said, in determining the evolution of a planet's atmosphere; first, there is the possibility that atoms and molecules can escape altogether, a process which is exaggerated the lighter the element, the smaller the planet and the higher the temperature of the gas; secondly, there is the extremely effective activity of the ultra-violet part of sunlight in breaking up the molecules of different substances. In the case of the terrestrial atmosphere, one of the chief uncertainties is the height at which diffusion becomes more important than large-scale mixing processes. This height depends on the temperature in the upper atmosphere, and, assuming that diffusion dominates from 160 km. to the escape layer at 300 km., and that the temperature increases linearly with height to 1,500°, or higher temperatures, at 300 km. or more above the Earth's surface, it is then found that the rate of escape of hydrogen is determined by diffusion and is about 10^7 atoms per sec. per sq. cm.

On this basis, the hydrogen from 20 gm. of water would escape from each square centimetre in $4{\cdot}5 \times 10^9$ years; the same will be true for Venus. The study of the ratio of helium-3 to helium-4 indicates a high temperature at heights of 500 km. above the surface of the Earth. The solid Earth is emitting hydrogen, ammonia, carbon monoxide and methane at unknown rates, and the oxidation of the latter would require the escape of a considerably larger amount of hydrogen than the above calculations would seem to permit. Another difficulty is that we still do not know the full details and history of the photochemical processes in the atmosphere; it is possible that initially planets possessed atmospheres which consisted largely of hydrogen, hydrocarbon compounds—like methane and water—and, on the Earth, following the escape of hydrogen, the oxidation of methane and the breaking up of water, that oxygen and carbon dioxide would ultimately remain with the oxygen serving as a protecting agent for the lower layers. On Venus it appears that carbon dioxide, not oxygen, has accumulated in the atmosphere, though the clouds on Venus are probably composed of water, possibly coloured by carbon compounds; C_3O_2 has been suggested as a possible colouring material. Absorption by carbon dioxide protects the water against photochemical decomposition in the lower atmosphere. The mixing ratio, hydrogen to water, is 150 times that on the Earth, but at no time could there have been rapid escape of

hydrogen due to decomposition of water below the tropopause. On Mars the escape layer is 1,400–1,800 km. above the surface, and if water vapour gets above the tropopause it will escape. The rate of escape of oxygen has been computed; results depend strongly on the height to which mixing extends. Carbon dioxide must be dissociated in the high atmosphere and oxygen atoms will escape if the high atmosphere is at 2,000° or higher. Carbon monoxide should react with water to give carbon dioxide and hydrogen, and the latter should escape. In this way a mechanism for the loss of large amounts of water may exist and the planet may once have had extensive oceans.

Dr. R. C. Sutcliffe read a paper on "The Influence of Condensation on Planetary Atmospheres". Dr. Sutcliffe raised the general question of genesis of circulatory flows in the atmosphere, whether the cycle of changes in a particular type of flow belong or not to the evaporation–condensation–precipitation cycle. Ordinary turbulence and the major depressions and anticyclones are called 'dry' in the sense that their genesis is independent of this cycle, whereas showers, thunderstorms, frontal activity, tornadoes and tropical hurricanes are 'wet' mechanisms which are driven by this latent-heat cycle. The main question posed by Dr. Sutcliffe is whether the general circulation of the atmosphere is essentially 'wet' or 'dry' in the above sense. The energy balance of the atmosphere, omitting dynamical and transport terms, has three components: sensible heat input by conduction, radiation balance (solar or terrestrial) and release of latent heat. Taking estimates given by Budyko, it appears that the sensible heat is a gain to the atmosphere in all latitudes (omitting the poles in winter) with little average meridional gradient, and overall radiation balance is a loss in all latitudes, again with little meridional gradient. Latent heat gain, on the other hand, has a very marked meridional variation with a main maximum in low latitudes and a secondary maximum in middle latitudes. The geographical pattern of energy sources and sinks has essentially the same shape as the precipitation pattern, and thus there is a strong presumption that the general circulation characteristics are substantially affected by the water cycle. The evidence from dish-pan experiments is not inconsistent with the present thesis, since it is possible that the jet stream in the experiment is the analogue of the polar front jet stream, but that the sub-tropical jet stream is a characteristic of the atmosphere linked with the direct meridional circulation of low latitudes, which is largely made possible by the water cycle.

A paper by Mr. J. S. Sawyer on "Jet Streams in the Earth's Atmosphere" concluded the morning session. Mr. Sawyer contributed a descriptive account of jet streams in the Earth's atmosphere—these being meandering belts of high-velocity westerly winds in the upper troposphere. They can be conveniently classed into three types: local jet streams, the circumpolar jet stream and the sub-tropical jet stream. Local jet streams arise primarily from the horizontal thermal gradients set up by the advection of warm and cold air around depressions and anticyclones. It is interesting to observe that there is usually ascent on the right, descent on the left and a cross-flow from right to left in such jets of magnitude 8–10 knots. The circumpolar jet stream is a feature of almost all maps of the flow in the upper troposphere, on which it appears as a meandering belt of strong winds around most of the hemisphere. It can be reproduced in the dish-pan experiments of Fultz and Hide, and is probably the result of the rotation of the system, differential heating and surface friction. Eddy motion probably plays a part in establishing it. The sub-tropical jet stream occurs around most of the hemisphere in latitudes 20–30° about the 200-mb. level, and attains wind speeds of more than 100 knots. It is less variable in position than the circumpolar jet and probably arises primarily from the conservation of angular momentum in the upper branch of the meridional Hadley-type cell circulation which exists in low latitudes. Sawyer mentioned that this type of high-velocity jet may be that in the symmetrical solution of the equations of motion on a rotating sphere due to M. H. Rogers.

The final session was opened with a paper by Mr. T. V. Davies on "The Theory of the Experiments on Convection in Rotating Fluids". Mr. Davies first commented upon a remark by Dr. Sutcliffe that the dish-pan experiments cannot reproduce the atmosphere. He pointed out that Starr and Long in 1953 compared the angular momentum transfer in the atmosphere and the experiment, and found similarity not only in the distribution of the transport but also in the mechanism of transfer. One of the principal features of the experiments of Fultz and Hide is that the flow patterns depend on a single parameter, the Rossby number $R_\theta = 2\theta$, where θ is Hide's parameter. Kuo and Davies have investigated the stability problem theoretically by the method of small perturbations, and have derived similar results. It follows from the analysis that wave number m is unstable when:

$$(1 + \tfrac{1}{2} R_\theta)\frac{h}{r_0} R_v^{\frac{1}{2}} x_{1m} < 2{\cdot}4$$

where r_0 and h are the radius and depth of the liquid, x_{1m} is the first zero of the Bessel function $J_m(x)$ and $R_v = g\alpha \dfrac{\partial T}{\partial z} \Big/ 4\Omega^2\rho$ is a type of Richardson number. This instability criterion indicates that the m wave can exist if the Rossby number and Richardson number satisfy an inequality. An inequality involving just R_θ alone is obtained if one makes use of a relation connecting R_θ and R_v found independently by Lorenz and Davies, namely:

$$\frac{h}{r_0} R_v = \frac{5}{16}(R_\theta)^2 \times (\text{Prandtl number})$$

in the case of symmetrical flow. This solution is equivalent to a relation between the vertical and horizontal gradients of temperature in a heated rotating liquid, and making use of it one obtains the instability criterion (for water):

$$x_{1m}\,(1 + \tfrac{1}{2} R_\theta)\, R_\theta < 1{\cdot}6$$

which agrees very well with the experimental results for low wave numbers $m < 5$ but diverges increasingly from them at higher wave numbers, possibly due to the inadequacy of the R_v, R_θ relationship. The problem of vacillation mentioned by Hide is a non-linear phenomenon not covered by the above theory.

Dr. J. G. Charney followed with a paper on the "Theory of the General Circulation of the Atmosphere". Dr. Charney emphasized first of all that in

trying to attain a complete theory of the general circulation, one must take into account the interaction of the mean zonal field of motion and the eddy departures from the mean, since these are not secondary features of the flow field but primary mechanisms in the energy transfer process. The large-scale eddies owe their origin to an instability of the thermally driven mean flow but, having developed and grown to a limiting size (the perturbation grows until the rate of gain of energy from the potential energy of the mean flow balances the rate of loss of kinetic energy into the mean flow), they then become permanent mechanisms of transfer.

In setting up this problem mathematically, use is made of the quasi-geostrophic approximation for the horizontal flow field, and a two-layer model is used for replacing the continuous three-dimensional field of motion—the interaction between the flow at the two levels being essentially the same as that between two superimposed homogeneous incompressible layers of differing density; this model gives realistic conversions of potential to kinetic energy, but has the disadvantage that the vertical distribution of temperature must be prescribed. The atmosphere is divided into the two layers 0–500 mb. and 500–1,000 mb.; the Rossby-type atmosphere is taken in which the variable Coriolis parameter is essentially a linear function of north–south distance and the heating supplied to a vertical column of this atmosphere obeys radiational laws. This differs from Phillips's recent general circulation solution in which the sources of heating are fixed.

The method of solution breaks down into the following steps: the steady-state wind and temperature distribution are calculated, assuming axial symmetry and the quasi-geostrophic approximation arising from solar heating; it is observed that this circular vortex is unstable. By means of first-order perturbation theory, that wave is calculated which has the greatest growth-rate; the only unknown factor concerning this wave is then its amplitude factor. Assuming the perturbation attains a limiting amplitude, a second calculation is made of the new zonal velocity and temperature distributions involving the unknown amplitude. If use is then made of the energy condition for the limiting perturbation, a specific value can be obtained for the amplitude. This is, of course, a numerical and not an analytical treatment.

The results obtained may be summarized as follows: in the absence of eddying motion, there are westerly winds mainly in the upper level, 25 m./sec. maximum at 45°. This distribution is modified by the eddy exchange process; about 20 m./sec. is added to wind velocities at 45° at both levels. It reduces the westerly zonal flow to zero near 22½° and 67½°; polewards of 67½° and equatorward of 22½°, upper and lower winds become slightly easterly. The pole-equator temperature contrast is considerably reduced by the eddies from 45° C. to about 20° C. The meridional motion in the symmetric case is a direct cell with a maximum horizontal velocity of 10 cm./sec., whereas the eddy process gives rise to a three-celled circulation. This is in broad general agreement with observation.

Dr. E. T. Eady read a paper on "The Physical Parameters characterizing the Dynamics of Planetary Atmospheres". He pointed out, first of all, that for the large-scale meteorological problems the Reynolds number is so large that the resulting turbulent flow patterns are well beyond the laminar régime. The second parameter introduced was the Richardson number, $Ri = g\frac{\partial\rho}{\partial z}\Big/\rho\left(\frac{\partial u}{\partial z}\right)^2$, where $\partial\rho/\partial z$ is a vertical derivative, which is a local parameter governing the stability of air flows of variable density: $Ri < 0$ produces convection, $0 < Ri < 1$ gives the criterion for the growth of meridional circulations, $Ri > 1$ produces circulatory type flows with slight vertical motion. Two numbers closely associated with Ri are $a = g\frac{\partial\rho}{\partial y}\Big/\rho f^2$, where f is the Coriolis parameter and $\partial\rho/\partial y$ a horizontal gradient of density and $b = g\frac{\partial\rho}{\partial z}\Big/\rho f^2$, the former being related to the Rossby number which enters into instability criteria. The Richardson number may be interpreted as the ratio of potential energy available to kinetic energy available to an element of fluid, and if Ri is large it is then clear that the eddying energy source is the potential energy. Also, it is clear that in regions of the atmosphere where electromagnetic forces are no longer negligible, one can introduce a non-dimensional parameter M which is the ratio of the magnetic energy available to the available potential energy, namely:

$$M = \mu H^2/gz^2\frac{\partial\rho}{\partial z}$$

M clearly increases in the vertical due to the decrease in density; M small implies that the charge moves with the fluid. In ionospheric regions where the mean free path is large, the all-important parameter is the ratio of the magnetic energy μH^2 to the kinetic energy mV^2 of the charged particles.

The main problems which seemed to have been dominating the discussions were summed up by Prof. P. A. Sheppard. Perhaps the most significant feature, said Prof. Sheppard, was the evidence of jet streams not only in our own atmosphere but also in other planets and in experimental work which Hide described. What is equally striking is that the reason for jet streams is still obscure. The fact that there is a transfer of westerly angular momentum polewards from the equatorial region does not, in itself, lead us to expect a sharp jet stream. Sawyer's views may imply 'that big jets grow from little jets', but on the other hand it is worth while bearing in mind that the tight horizontal temperature gradients, with the consequent development of a jet, may be associated with unstable baroclinic wave development. The question of the maintenance of the jet stream against turbulent diffusion at the boundaries has been raised, and in this connexion it is possibly important to bear in mind that the two-dimensionality of the flow patterns may imply a lesser amount of turbulent dissipation. The precise reasons for the existence of two jets is not clear, and similarly ocean jets such as the Gulf Stream are not yet adequately explained. Veronis has suggested that there may be thermal processes involved here which have not been sufficiently elucidated. The work of Kuo and Davies on instability of the dish-pan flows raises some important questions concerning earlier work on instability of atmospheric zonal flow patterns, in which the variation of the Coriolis parameter with latitude played a dominant part, but this is absent completely in the dish-pan experiments. Does the

experimental dish-pan type flow actually carry over to the atmosphere, in which the heat sources are to some extent different? (One serious drawback of theoretical attempts up to the present is that the vertical temperature gradient is prescribed initially and is not a product of the solution of the equations.) The processes of momentum transfer in the experimental work and in the atmosphere are now fairly fully understood; energy transfer processes are also understood and Dr. Sutcliffe's results may be summed up by saying that the presence of water vapour in the energy-transfer problems alters the tempo rather than changes the pattern.

So far as the planets are concerned, Prof. Urey's work demonstrates that chemical composition has to be brought in in building up the complete picture of the general circulation. Dr. Goody has made it quite clear that the large-scale dynamical problems for the atmosphere of Mars may be much simpler for meteorologists than our own atmosphere, due to the fact that its water vapour content is so much less. In the case of Jupiter, where there is a variation of the mixing ratio with height, it is possible for there to be one atmosphere overlying another with little or no interaction, and this raises quite difficult problems of interpretation. T. V. DAVIES

THE EUGENICS SOCIETY

ON December 4 the Eugenics Society held a dinner under the presidency of Sir Charles Galton Darwin, in celebration of its first fifty years of active life. The jubilee dinner was the occasion of two special events. The first was the presentation of the Galton Medal to Dr. C. P. Blacker. This Medal, a mark of high distinction and esteem, is the highest honour in the gift of the Society. It has been awarded on a single previous occasion, a dozen years ago, to Sir Alexander Carr-Saunders, later to be president of the Society, who was present and spoke at the dinner.

Dr. Blacker, now honorary secretary of the Society, was its general secretary for the twenty-one years during 1931–52, so spanning the presidencies of Sir Bernard Mallet, Sir Humphry Rolleston, Lord Horder and Sir Alexander Carr-Saunders.

The presentation of this rare award is testimony to Dr. Blacker's great knowledge, zeal and vigour on behalf of the Society. It is very largely through his writings and influence that the Society has been able to lead public opinion in a controversial field and age.

The second special feature of the jubilee was the issue of the Society's revised Statement of Aims. This document, as well as treating of eugenic science, studies and policies, provides an impressive list of the past activities of the Society. They afford a convincing indication of the way in which the Society has often been able to lead—albeit quietly and by stimulation in the right quarters at the right time. Possessing freedom, by the good fortune of endowment, the Society has been able to initiate and catalyse chosen efforts and researches, frequently doing so by help to cognate societies, such as the International Planned Parenthood Federation, the Family Planning Association, the British Social Biology Council, and others.

Prominent among the Society's activities pursued by such means have been Lidbetter's classic researches on the social problem group, and later work on problem families; Baker's work in the 'thirties on the elaboration and testing of chemical spermicides as a stage in the improvement of contraceptives without which appropriate differential fertility cannot be brought about; Lewis's work on morbid inheritance; and the Population Investigation Committee (of which Carr-Saunders and Blacker were joint founders), which was the forerunner of the Royal Commission on the Population of Great Britain. Further, there have been two especially close collaborations with Political and Economic Planning on population policy for Great Britain a decade and more ago, and much more recently on world population and resources. An inquiry into promising families will soon be published.

The Society's journal, the *Eugenics Review*, has been published as a quarterly since 1909, and following the Second World War there has been issued additionally a series of important occasional papers by Blacker, Burt, Thomson, Terman and others.

The Society's jubilee also coincides with a change in the general secretaryship. Dr. C. O. Carter, who succeeded Dr. Blacker in 1952, has now joined the Medical Research Council Clinical Genetics Research Unit at the Hospital for Sick Children, Great Ormond Street. His place has been taken by Dr. G. C. L. Bertram who, after seven years as director of the Scott Polar Research Institute in Cambridge, has recently spent a period in New Zealand as William Evans visiting professor in the University of Otago.

The aims of the Society may be summarized as being: to study the influences which may modify inborn human qualities; to formulate and support policies for developing these qualities to the utmost advantage; to promote research on eugenic problems; to foster a responsible attitude to parenthood; and to guide public opinion in these matters.

The Society's address is 69 Eccleston Square, S.W.1.

WORK STUDY

IN the four years of its existence the European Productivity Agency has done much to stimulate increased productivity in industry through conferences, courses, visits of consultants, publications and other means. Some of its activities have been of little value to progressive organizations and have been unnoticed and unheeded by others. In the main, however, the Agency has provided a most valuable service in acting both as a stimulant and as a medium for promoting exchange of useful ideas and methods between firms in the participating countries. The majority of its reports have been welcomed by those looking for new ideas and techniques to increase productivity.

Of all the reports the Agency has produced, "Labour Management on the Farm"* will almost certainly be regarded as one of the most valuable. It contains information which has been culled from innumerable sources and which has never appeared before in one volume. It is of direct and practical value to the thinking farmer who is prepared to revise his methods to improve his efficiency; it has been carefully planned and well written.

The report owes its genesis to a seminar organized on behalf of the European Productivity Agency by

* "Labour Management on the Farm". Pp. 171. (Paris: European Productivity Agency of the Organization for European Co-operation, 1957.)

the Ministry of Agriculture, Fisheries and Food of the Netherlands at Wageningen during July 9–18, 1956. The seminar was attended by approximately 45 participants from 12 member countries of the Organization for European Economic Co-operation—Austria, Belgium, Denmark, France, Germany, Italy, Luxembourg, the Netherlands, Norway, Sweden, Switzerland and the United Kingdom. Participants included specialists, teachers and advisors working on farm work simplification and labour management.

The programme of the seminar provided for discussions and exchange of information on the technical and economic importance of labour management in agriculture; on methods for work study and their application; on development and use of standard data and allowances in labour planning and control in relation to farm wages; on advisory and teaching activities in farm work simplification and labour management; and on the principles for maintaining good labour relations on the farm. Practical demonstrations of work study methods were arranged at the Institute for Agricultural Engineering and Rationalization at Wageningen.

Although it is fully realized that many questions concerning labour relations on the farm are arranged under agreements between associations of employees and employers respectively or by means of official regulations, the present report is primarily concerned with the relations between the individual farmer and his workers.

After defining the objectives of farm-work simplification and labour management on the individual farm, the report presents an illuminating account of work-study technique applied to farming practice as well as current research in work simplification. There is, for example, an impressive flow process chart, analysing the handling of straw on a farm; it was found that the straw was lifted fifteen times before reaching its final destination. There is also a man-machine process chart of machine milking which shows that the machine was idle for half the time the milking task was being performed. In another example, a string diagram was prepared to show the paths travelled by two pigmen when feeding and watering pigs; the ensuing changes led to a reduction of 100 walking miles each year.

To show that work study leads to genuine and practical improvements on the farm, and to give the farmer guidance in developing the principles of work simplification on his own farm, the report includes five studies where work study has been applied to agriculture. These are: the farm work diary—as a means of research and extension in the field of labour management; work study as a guide for setting piecework rates; planning farm buildings to save time and energy; the role of work study in the development of machines and hand tools; and the role of work physiology in dealing with problems of labour management.

The section on farm buildings gives useful information about the conversion of old buildings; the section on work physiology not only includes well-substantiated advice about the prevention of fatigue but also recommendations about the kinds of tools and barrows which are most suitable for farm workers. Even the notoriously conservative farmer might be tempted to try buckets with a flattened side after reading how their use has led to a considerable reduction in fatigue.

The authors of the report are aware that the introduction of method study and work measurement is unlikely to be accepted on farms where labour relations are bad. They recommend means whereby good labour relations may be built up and maintained on the farm and give detailed information about the principles which must govern the introduction of a wage incentive plan. This is supported by illustrations of cases where wage incentive schemes have been introduced.

Since the report is more likely to be seen and used by organizations like county agricultural advisory committees than by individual farmers, it includes sections describing the ways in which an advisory programme and labour management and adequate training facilities could be developed; they are as useful and practical as the rest of the report.

The detailed bibliography contains accounts of fundamental researches and of immediately applicable investigations like those concerned with the organization of raspberry picking with chips and punnets and of the use of motion and time study in planting cabbage and celery by hand.

THE PROBLEM OF THE 'AMPHIOXIDES' LARVA

By QUENTIN BONE

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THE remarkable 'amphioxides' larvæ that were described in detail by Goldschmidt[1] and Gibson[2] appear to be the larvæ of three different species of Acraniate. When these larvæ were first described, it was supposed that they were adult animals, and they were placed in a separate genus, *Amphioxides* (Gill[3]).

The three forms which were later distinguished, *Amphioxides pelagicus* (Gunther); *A. valdiviae*, Goldschmidt; and *A. stenurus*, Goldschmidt, were all rather similar, differing from each other in size, myotome number, and in various other characters such as the form of the tail fin and rostrum.

These animals are unlike the well-known amphioxus larva (that is, the larvæ of *Branchiostoma lanceolatum*), for although they are superficially similar in appearance, they are evidently animals that spend much longer in the plankton, growing to a larger size before metamorphosis; from this longer growth-phase arises their differences from the amphioxus larva. When fully grown, but before they have begun metamorphosis, they may be 9 mm. or more long (twice the size of the amphioxus larva at metamorphosis), and yet possess no trace of the atrium except at the extreme hinder end of the body. The fully grown specimens of all the species known possess a single row of 27 median gill slits, which correspond to the primary series of gill slits of the amphioxus larva.

In some of the larger specimens that have been found, there are large gonad rudiments in a row upon

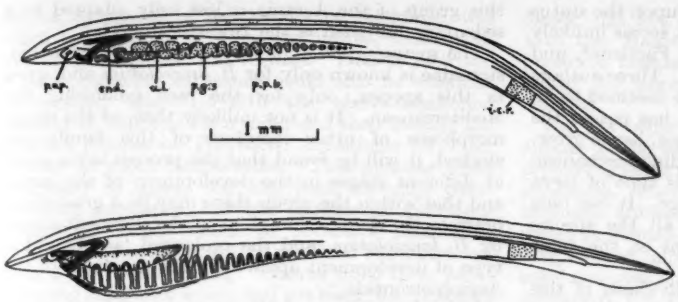

Fig. 1. *End.*, endostyle; *p.o.p.*, præ-oral pit; *p.p.b.*, peripharyngeal band; *p.g.s.*, primary gill slits; *u.l.*, edge of upper lip; *i.c.r.*, ilio-colonic ring

the right side of the body only. It was for this reason that they were at first believed to be adult forms; Goldschmidt made the genus the type of a new family of Acrania, the Amphioxididae (allied by the asymmetry of the gonads to the Epigonichthyidae), Goldschmidt[4].

Very shortly afterwards, both Goldschmidt and Gibson found specimens that had metamorphosed, and it became clear that the animals were in fact Acraniate larvæ. But this clarification of the situation has not yet gone as far as it might, for not only is it not clear to which adult species the larvæ are to be assigned, but also it is necessary to consider the possibility (first suggested by Goldschmidt) that any given species of Acraniate may possess alternative larval forms. This suggestion gains support from the single specimen of an 'amphioxides' type of larva which has been found in the North Sea[5]. This larva had 19 gill slits, in a single row; it was 5 mm. long and possessed 61 somites but no gonad rudiments. It is certain that this larva is to be assigned to *Branchiostoma lanceolatum*, which normally produces an 'amphioxus' larva metamorphosing at the stage when there are 14–15 primary gill slits, and the larva is 4·5 mm. long.

It is interesting that the amphioxus larvæ which were found at Plymouth in 1892[6] possessed 16–17 primary gill slits (their length was not stated, and I have been unable to locate these specimens).

Apart from these larvæ from the Channel and the North Sea, none of the known species of 'amphioxides' larva can be definitely assigned to an adult species of Acraniate. It is probable (but not certain) that *Amphioxides pelagicus* may belong to *Asymmetra lucayanum*; for the other forms of larva, no adult form has been suggested.

By the kindness of Prof. M. Blackburn and Dr. Munro (of the C.S.I.R.O., Cronulla, New South Wales), I have been able to examine some specimens of the larvæ of *Paramphioxus bassanus* (Gunther), an Australian Asymmetrontid, which were collected in the Bass Strait area. The occurrence and distribution of these larvæ have been briefly discussed by Blackburn[7].

They are 'amphioxides' larvæ of a very similar appearance to those previously described; in Fig. 1 the upper drawing shows the appearance of a large fixed specimen, and the lower, the probable appearance of the larva in life.

Fig. 1 illustrates the largest larva received (6·4 mm.), which had 27 median gill slits. In none of the specimens was there any trace of gonad rudiments. Compared with *Amphioxides pelagicus* of equivalent maturity (the same gill slit number), the present species is smaller, which may account for the absence of the gonad rudiments.

The chief distinguishing character of these larvæ is that they possess a much greater number of myotomes than the other forms described. The largest number for *A. pelagicus* is 68, and for *A. valdiviae* and *A. stenurus*, 70. In the present larvæ, the smallest specimens had 74 myotomes, and the usual number for both large and small was 78. In addition, in these larvæ, the tail fin begins at the level of the 43rd myotome (as compared with the 23rd–25th in *pelagicus*, and the 32nd–33rd in *valdiviae*).

Lastly, the fin-ray boxes, which form a continuous dorsal series, are arranged 4 to a myotome throughout, as compared with 5 in *A. valdiviae*, and 2–4 in *A. pelagicus*.

These larvæ are interesting, for they are the first larvæ of the 'amphioxides' type that can be certainly assigned to a known adult species; also, they show some stages in the metamorphosis of this type of larva which indicate that the process is somewhat different from that taking place in the amphioxus larva.

In the complex re-assortment of the gill slit number, involving both the disappearance of slits already formed and the appearance of new slits, that takes place during the metamorphosis of the amphioxus larva, there is a stage when the larva possesses 8 pairs of gill slits, known as the 'critical' stage[8]. At this stage, the larva pauses for a period before further changes take place; it is sometimes supposed that it represents a significant phase in the recapitulation of the evolutionary history of the Acrania. However this may be, it seems that the 'amphioxides' type of larva does not exhibit a critical stage in its metamorphosis, which appears to be a relatively gradual process.

Gibson's description of the two metamorphosing individuals of *Amphioxides pelagicus* showed that if these larvæ went through a 'critical' stage, then it was when they possessed 18 pairs of gill slits. In the largest of the present larvæ, there are 27 primary gill slits, and the rudiments of 5 secondary slits at the front of the pharynx, of which the first and latter are smaller than the others. This condition suggests that the secondary series of slits in the 'amphioxides' type of larva appear gradually from in front backwards, as the primary slits become reduced from 27 to 18. That is to say, there does not appear to be a 'critical' stage in the metamorphosis of this type of larva.

It may perhaps be suggested that the 'amphioxides' type of larva (apart from the secondary asymmetry of the gonads) is the nearest living animal to that which by pædomorphosis gave rise to the Chordata. The early Protochordate larva ancestral to the Chordata very probably had a prolonged period of growth in the plankton, resulting (as in the 'amphioxides' type of larva) in increase in size of the body, and the appearance of the gonads before metamorphosis. Eventually, total neoteny occurred, and the Chordate line arose.

Various views have been expressed upon the status of the 'amphioxides' type of larva; it seems unlikely that that advanced by Bigelow and Farfante[9], and supported by Berrill[10], can be correct. These authors suppose the 'amphioxides' larva to be destined to an eventual death as a larva, because it has passed the 'critical' stage without metamorphosing, hence growing to a larger size than its ciliary feeding mechanism can support. It is probable that this type of larva does not pass through a 'critical' stage. It has long been known to metamorphose; in all the species discovered, the metamorphosis begins at the same 27-gill slit stage.

The rarity of metamorphosing individuals of this type of larva in the plankton suggests that they may perhaps metamorphose elsewhere than at the surface layers. They possess the same adhesive organs upon the metapleural folds as does the amphioxus larva; possibly they may spend the latter part of larval life upon the sea bottom. Little is known for certain of the ecology of any Acraniate larva; the accounts in the literature of the habitat of the amphioxus larva vary from van Wijhe's remark that "the habitat of the amphioxus larva seems to be chiefly the sea bottom" (van Wijhe[11]) to the more usual statements that they are throughout larval life pelagic organisms.

There are six species of Acraniate with asymmetrical gonads (which are sometimes classified as a single family, the Asymmetrontidae, and sometimes divided into this family, and a second, the Epigonichthyidae); there are four forms of 'amphioxides' larvæ known. It is possible that all these Acraniates possess this type of larva, and are thus distinct from the Branchiostomidae, in which this type of larva is a great rarity. It is significant that the adults of *Asymmetron lucayanum* are found at times in plankton hauls; perhaps this group of the Acrania is less fully adapted to a sedentary life than is the Branchiostomidae.

The metamorphosis of the larvæ of the Branchiostomidae is known only for *B. lanceolatum* and, even in this species, only for the race inhabiting the Mediterranean. It is not unlikely that, as the metamorphoses of other members of this family are studied, it will be found that the process takes place at different stages in the development of the larva, and that within the group there may be a graduation between the classical 'amphioxus' development shown by *B. lanceolatum*, and the prolonged 'amphioxides' type of development apparently characteristic of the Asymmetrontids.

It is the purpose of the present article to direct attention to the unique nature of the 'amphioxides' type of Acraniate larva; much more needs to be discovered about their distribution and ecology before their status can be satisfactorily determined. It is suggested that this information will throw important light upon the problems of the origins of the Acrania and the Chordates from the Protochordate stock; in such speculations, the 'amphioxides' larva has been curiously neglected.

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PLASMA PAIN-PRODUCING SUBSTANCE AND BLOOD CLOTTING

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WHEN plasma is brought into contact with glass, pain-producing, uterus-stimulating activity rapidly develops and then decays[1]. The pain-producing substance is probably a polypeptide, and its formation appears to involve activation of a proteolytic enzyme which acts upon a substrate to produce the pain-producing substance, which is then rapidly destroyed by a peptidase in plasma. The development of the pain-producing substance is analogous to the initiation of blood clotting by glass[2]. Both sets of phenomena are independent of calcium and of platelets and both are inhibited by soya bean trypsin inhibitor. In the present work the relation between the two series of reactions has been studied.

The addition of potent, protein-free preparations of the pain-producing substance, obtained by aqueous or alcoholic extraction of activated plasma[1], to preactive plasma had no effect on clotting, showing that the pain-producing substance is not itself an intermediary in the process of clotting induced by contact with glass.

In studying other possible inter-relations between formation of pain-producing substance and clotting, cell-free, citrated plasma was prepared in 'Polythene' or silicoued containers and then exposed to the action of glass ballotini[3]; the pain-producing substance was assayed on the isolated rat uterus, and in some experiments also for pain-production on an exposed blister base[1].

A two-stage reaction has been demonstrated for initiation of clotting by glass. An attempt was therefore made to establish the existence of two stages in the formation of pain-producing substance.

Plasma was rotated in a silicoued glass tube with an equal weight of glass ballotini (surface area about 200 cm.^{2}/G); concentration of the substance reached a peak after 2–3 min. and rapidly declined to a negligible value after about 10 min. When such

plasma, exhausted of pain-producing substance, was added to a sample of preactive plasma, fresh pain-producing substance was formed. Plasma deprived of pain-producing substance could also be obtained by rotating with 1/5–1/10 the above-mentioned quantity of ballotini for 5 min., and then leaving the decanted plasma in 'Polythene' containers for 1 hr. or more at room temperature. This plasma, when re-exposed to glass, did not itself develop pain-producing substance, but was capable of activating a relatively large volume of preactive plasma to produce the substance, with a maximal concentration about 2 min. after mixing. Plasma freed from pain-producing substance which had not been re-exposed to glass did not activate preactive plasma.

Drs. D. Armstrong and J. B. Jepson found that the pain-producing substance which was formed by the two-stage activation was indistinguishable in pharmacological tests from that formed by the usual one-stage activation. There was also no difference in their rates of inactivation by chymotrypsin and by bacterial aminopeptidase.

It thus appears that when plasma is exposed to glass a substance, which has been called 'contact factor', is first formed. This 'contact factor' then initiates further reactions which lead to formation of pain-producing substance.

The time-course of development and decay of 'contact factor' was investigated as follows: 1 vol. of ballotini-activated plasma (previously exhausted of pain-producing substance) was incubated with 2 vol. of preactive plasma at room temperature. The development of the substance was measured by applying 0·1 ml. of the mixture to the rat's uterus in a 5-ml. organ bath. By varying the period of contact of the exhausted plasma with ballotini, it was found that the activity of 'contact factor' reached a peak after 2 min., and declined to negligible values within 20–30 min. If at any stage the plasma was removed from the glass, 'contact factor' decayed rapidly, falling to less than 10 per cent of its original value within 5 min. at room temperature. The rate of decay of 'contact factor' was slower when the exhausted plasma had been pre-heated at 56–58° C. for 20–30 min.

'Contact factor' could also be formed from the globulins precipitated from plasma between 25 and 45 per cent saturation with ammonium sulphate. Decay of this fractionated 'contact factor' was even slower than that of pre-heated plasma. Addition of whole plasma to such a fraction increased the rate of decay of the fractionated 'contact factor' to that found in untreated plasma. Thus decay of 'contact factor' appears to be due to an inactivator, which is partly destroyed by heating and is largely removed by fractionation.

These findings closely resemble those described for the initiation of blood clotting by glass[2]. Other points of agreement are as follow.

The 'contact factor' is not affected by prior treatment of preactive plasma with aluminium hydroxide or barium sulphate. Its development is not affected by prior heating of plasma to 56–58° C. for 30 min., but 'contact factor' is not formed in plasma previously heated to 60° C. for 20 min. The reacting system is found in 25–45 per cent saturated ammonium sulphate fraction of plasma. 'Contact factor' develops normally in the plasma of patients with hypoprothrombinæmia, deficiency of factors V and VII, hæmophilia, Christmas disease or thrombocytopænia[3,4]. 'Contact factor' did not develop in the plasma of a patient with the 'Hageman trait'[4,5], although the patient's preactive plasma could act quite normally as 'substrate' for normal 'contact factor' in a two-stage reaction.

On the other hand, both activation and decay appear to be slower when measured by the clot-promoting effect than by production of pain-producing substance. Further, in patients with 'plasma thromboplastin antecedent' deficiency there was a partial defect in formation of 'contact factor' as assessed by coagulation[5], although formation of pain-producing substance was normal. These differences can now be accounted for by the demonstration that another stage, involving 'plasma thromboplastin antecedent', is necessary for the initiation of coagulation by contact with glass. 'Plasma thromboplastin antecedent' may form a substrate for the action of 'contact factor' in clotting in the same way as the precursor of pain-producing substance does in the formation of the substance. A suggested scheme of events, compatible with all these observations, is shown in Fig. 1.

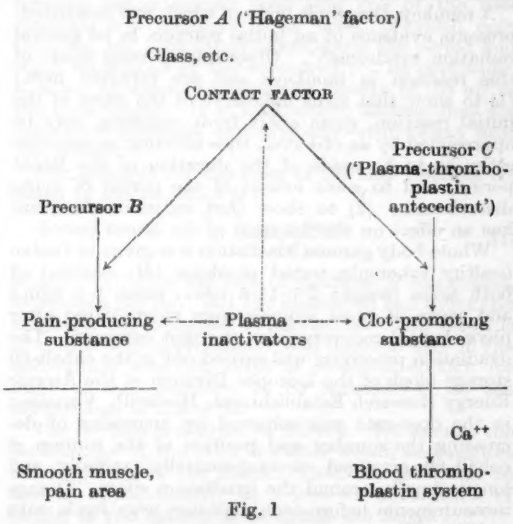

Fig. 1

Apart from glass, certain other surfaces are capable of activating both pain-producing substance and blood clotting. The exact nature of the relevant surface properties is still under investigation, but an important clue may lie in the finding that dried silica gel and alumina, which are inactive to begin with, acquire considerable activity after heating above 1,000° C. The full details of this investigation will be reported elsewhere.

I am indebted to Prof. C. A. Keele for his continued help and advice and to Dr. R. G. Macfarlane for his interest and his valuable criticism. I wish to thank Dr. D. Armstrong for her help with the experiments on the pain area and Dr. R. M. Hardisty for supplying specimens of plasma from his patient.

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LETTERS TO THE EDITORS

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The General Radiation Syndrome: Initial Reaction in the Monkey

The initial reaction of the general radiation syndrome in man is characterized by a latent period, a period of acute disturbance and a recovery period. During the period of acute disturbance the predominating symptoms are fatigue, headache and nausea and some people vomit and have colonic evacuation[1,2]. The duration of the latent period, that is, the time from the commencement of irradiation until the onset of symptoms, not the onset of vomiting, is dependent on the surface-dose, body-size and anatomical site of irradiation[3,4]. Also a significant inverse relationship between dose-rate and the length of the latent period has been reported during the therapeutic administration of radioiodine[5].

A monkey, the whole body of which was irradiated, presents evidence of an initial reaction in its general radiation syndrome[6,7]. Observations were made of this reaction in monkeys and are reported here: (1) to show that signs indicative of the onset of the initial reaction, quite apart from vomiting, may be appreciated by an observer, thus allowing an accurate estimate to be made of the duration of the latent period, and to some extent of the period of acute disturbance; (2) to show that radiation dose-rate has an effect on the duration of the latent period.

Whole-body gamma irradiation was given to twelve healthy tuberculin-tested monkeys (*M. mulatta*) of both sexes (weight 3·7–11·5 kgm., mean 6·9 kgm.) and seven of these animals were re-irradiated after physiological recovery from the first exposure. The irradiation procedure was carried out in the cobalt-60 storage block of the Isotopes Division at the Atomic Energy Research Establishment, Harwell[8]. Variation in the dose-rate was achieved by increasing or decreasing the number and position of the sources of cobalt-60 arranged circumferentially, radially and longitudinally around the irradiation space. Dosage measurements before each exposure were made with a 100-r. Victoreen ionization chamber placed in a phantom made of bolus bags[9]. The mean whole-body dose calculated from these measurements was 450r. with two exceptions of 470r. and 480r. The animals were housed individually and allowed food (diet 41 rat cubes) and water until irradiated. The animals were trained to enter the handling cage, the irradiation cylinder, and to accept food from the hand. At no time were the animals restrained or harshly treated. After irradiation the animals were returned to their own living quarters and a close watch kept on their activity, behaviour and appetite. A cinematograph film was made of two animals.

The onset of the initial reaction could be readily detected by a quite sudden change in the animal. The monkey would hang wearily from the cage roof, head on chest, or sit dejectedly in a corner, and at times lie down on the floor of its cage. Loss of appetite accompanied this change. In most animals these signs would pass off only to return in a few minutes in an exaggerated form, accompanied by retching and vomiting. Waves of the latter signs recurred; but gradually their severity lessened, the interval between them lengthened and they ceased in 2 hr. or so. Appetite then returned, and no further vomiting was observed in the later course of the syndrome.

Table 1. The Dose, Dose-Rate and Duration of Latent Period in Nineteen Irradiated Monkeys following Whole-Body Gamma Radiation

Dose (r.)	Dose-rate (r./min.)	Latent periods (min.)
450	124·0	35, 34, 32
450	103·0	31, 36, 30
450	96·7	34, 33, 36, 31
450	53·0	31, 34, 28
480	15·0	75
470	14·5	80
450	13·0	108
450	7·0	90, 90, 75

The time from the commencement of irradiation to the first observed change indicative of the onset of the initial reaction was recorded as the latent period (Table 1). It will be seen that as the dose-rate increased from 7·0 r./min. to 53·0 r./min. the duration of the latent period decreased from some 90 min. to about 30 min.; but its length was not altered by further dose-rate increments.

With the lower dose-rate irradiations the onset of the symptoms of the initial reaction in the monkey may be observed 10 min. or more before vomiting, but with the higher dose-rate exposures vomiting sometimes occurred with the first wave of symptoms. These observations suggest that dose-rate is another factor in the development of the initial reaction of the general radiation syndrome in the primate, although the number of monkeys exposed was small. A striking likeness is apparent between the initial reaction in the monkey and radiation sickness seen in therapeutic practice. There was no evidence that sex and previous irradiation, provided full recovery from the first exposure had been made, play a part in the development of the initial reaction of the general radiation syndrome in the monkey.

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Radiation Lethality and Local Tissue Damage in Histamine-depleted Rats

THE liberation of histamine from cells damaged by ionizing radiations is considered to play an important part in certain radiation changes, particularly in skin erythema and in certain aspects of the acute radiation syndrome[1]. While some elevation of plasma histamine is said to occur after total-body irradiation[2], estimations of tissue histamine following irradiation have been reported unchanged[3] or lowered[4]. The administration of histamine at the time of irradiation, to animals subjected to lethal doses of total-body irradiation, has been found to afford a weak but variable protective effect[5].

In order to test the hypothesis that release of available tissue histamine conditions the general and local effects of irradiation, rats were 'depleted' of tissue histamine, prior to irradiation, by intraperitoneal administration of a histamine liberator, compound 48/80 (ref. 6). It has been shown[7,8] that this substance reduces tissue histamine in skin and certain other tissues to very low levels—less than 10 per cent of normal values for skin, subcutis, mesentery and omentum. By adopting a chronic dosage schedule, as described by Feldberg and Talesnik[7], a low level of tissue histamine is reached by the third day in 100–150 gm. rats.

In the first experiment, groups of rats on the third day of histamine depletion received a dose of 1,000 r. total-body irradiation, measured with back scatter, using a 250-kV. source of X-rays, and increasing doses of 48/80 were continued throughout the total period of observation. Each group consisted of twenty animals, selected from litters of inbred Canberra black laboratory stock rats, the litters being equally divided between the two groups.

Comparison of the irradiation lethality curve obtained for the histamine-depleted rats after irradiation with control groups receiving injections of saline, showed an increased mortality-rate in the histamine-depleted animals. The mean survival-time for histamine-depleted animals was 4·91 (± 1·04) days, compared with 8·67 (± 4·10) days for the controls. On the seventh day after irradiation, all histamine-depleted animals had died, whereas 60 per cent of control rats were still alive.

In the second experiment, groups of histamine-depleted albino rats and controls receiving injections of saline (ten animals per group) each received an X-ray dose of 4,000 r. to a 3·5-cm. diameter circular field of skin, using a 30-kV. beryllium window X-ray source, giving a half-value depth dose of 2,000 r. at 1 mm. It was found that the histamine-depleted animals developed radiation changes in the skin significantly earlier than controls, the skin erythema was more intense, and the final tissue damage was considerably increased.

It is considered that these results indicate that acute radiation shock and lethality, radiation erythema and local tissue damage cannot be satisfactorily explained on the basis of release of histamine. In fact, the results suggest that lack of available tissue histamine results in a lessened protection to irradiation damage, and that histamine takes a physiological role in the inflammatory response to such injury.

The details of these results, together with other investigations now in progress, will be recorded in detail later.

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Estimating the Life of a Satellite

IT is perhaps not generally known that one can forecast rather simply how long one of the new satellites will continue in an orbit, provided only that one has good information about the period and some knowledge of the eccentricity. In particular, it is not necessary to know the density of the air or the scale-height. It is sufficient to assume that the resistance decreases exponentially with height near the perigee.

Our estimate for the span of life that remains for either of the satellites is :

$$0{\cdot}30\ \frac{h_{\max.} - h_{\min.}}{-\mathrm{d}T/\mathrm{d}t} \qquad (1)$$

where $-\mathrm{d}T/\mathrm{d}t$ is the rate of decrease of the period, in seconds per day, and the maximum and minimum heights h are expressed in kilometres. This result is of course only approximate, and depends also on the assumption that the orbit is eccentric enough for most of the resistance to be encountered on the perigee side of the orbit.

The formula is derived as follows. We assume the eccentricity of the orbit is rather small, and neglect the ellipticity of the Earth. Then the orbit can be treated approximately as a sine-wave variation of height as the satellite goes round the Earth :

$$h = \text{constant} - A(t)\cos\theta \qquad (2)$$

(θ is the anomaly). The air-resistance near perigee will be important, so we measure heights h from some convenient datum near the height of perigee, say 200 km. above the Earth ; and we suppose the density of the air is :

$$\rho = \rho_0 \exp(-h/H) \qquad (3)$$

The effect of the resistance of the air is mainly to diminish the maximum height at apogee (by several kilometres a day) ; the gradual loss of height at perigee, though slight, is important because it brings the satellite into denser air than before. We denote the height at perigee by $z(t)H$, and equation (2) takes the form :

$$h = zH + A(1 - \cos\theta) \qquad (4)$$

($A = \frac{1}{2}(h_{\max.} - h_{\min.})$ is equal to the product of the eccentricity and the semi-major axis).

Now it can be shown from the dynamics of disturbed nearly circular orbits that, after one revolution, A decreases by an amount :

$$-\delta A = C_1 \int_{-\pi}^{\pi} \rho \cos\theta . d\theta \quad (5)$$

and the perigee descends by a distance

$$-H\delta z = C_1 \int_{-\pi}^{\pi} \rho(1 - \cos\theta) . d\theta \quad (6)$$

These integrals can be expressed exactly in terms of the Bessel functions I_1 and I_0, but it is sufficient for our purpose to insert approximations for cos θ and put :

$$\rho = \rho_0 \exp(-z) \exp(-\tfrac{1}{2}A\theta^2/H) \quad (7)$$

approximately, which leads to equations of the form

$$-dA/dt = C_2 A^{-1/2} \exp(-z) \quad (8)$$

$$-dz/dt = \tfrac{1}{2}C_2 A^{-3/2} \exp(-z) \quad (9)$$

These simultaneous equations give the secular change of the orbit. They are easily solved, and yield :

$$A = C_3(t_0 - t)^{1/3} \quad (10)$$

Here t_0, C_1, C_2 and C_3 are constants.

When t approaches t_0 too closely, the present analysis breaks down because the orbit becomes too nearly circular, but a rough calculation indicates that the present satellites should not last more than one or two days beyond the extrapolated time $t = t_0$. It remains to find the actual value of t_0, and the easiest way to do this is to use Kepler's third law to get the decrease of the semi-major axis R in terms of the diminution of the period T. This gives :

$$-\frac{1}{R}\frac{dA}{dt} = -\frac{2}{3}\frac{1}{T}\frac{dI}{dt} \quad (11)$$

within the accuracy of our present approximations. The life still remaining is then given by :

$$t_0 - t = \frac{\tfrac{1}{2}A}{-dA/dt} = \frac{3T}{8R}\,\frac{2A}{-dT/dt} \quad (12)$$

using (10). The first factor $3T/8R$ is $\frac{3}{2}\pi/v$, where v is the velocity of the satellite : that is, about 0·30 sec./km.

By way of illustration, we have used the most recent data that happened to be at hand ; they were taken from a Moscow message in *The Times* of November 11.

	Satellite I	Rocket	Satellite II
Period (sec.)	5,683	5,609	6,211
Diminution (s./day)	2·94	6·3	2·3
Apogee, h (in km.)	810	695	1,650

From these figures we infer heights at perigee in the neighbourhood of 210 km. for all three. If the epoch of the Russian figures is about November 9, our rough calculation gives forecasts of January 10, December 1 and May 1958 respectively. No doubt better data exist by now, but these will serve as an illustration.

In the above calculation, rather drastic approximations have been made. But it appears that if one seeks much better accuracy than this, many extra complicating factors must be considered at once.

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Discharges in Hydrogen at the Ion Cyclotron Frequency

Attempts to find the optimum conditions for producing a highly ionized plasma in hydrogen have recently been described[1]. A microwave source was used, and the discharge tube was immersed in a magnetic field. It was found that a more efficient transfer of energy from the micro-wave field to the plasma took place when the operating frequency equalled the electron cyclotron frequency. We have carried out preliminary experiments to discover if such a selective absorption occurred when the applied frequency was equal to the ion cyclotron frequency. This frequency is given by $F = eH/2\pi mc$, where H is the magnetic field strength and m is the ionic mass.

The 'Pyrex' discharge-tube was a short cylinder, 8 cm. in diameter and 3 cm. between parallel faces. Electrodes mounted on the axis of the tube were used for providing a small Penning-type discharge to initiate a discharge when radio-frequency pulses were used. The tube was mounted between the poles of a permanent magnet, giving an axial field of some 3,000 gauss. A radial radio-frequency electric field was provided by means of parallel plate electrodes outside the discharge tube. Thus the tube bore a slight resemblance to the omegatron radio-frequency mass spectrometer.

The parallel plate electrodes formed part of a resonant circuit ($Q = 250$) which was coupled to a 150-watt radio-frequency source, with a frequency range of 3·8–5·9 Mc./s. The radio-frequency voltage across the discharge tube was measured by a diode valve voltmeter and peak voltages of 2·5 kV. were obtained.

The hydrogen pressure in the sealed-off discharge tube could be adjusted conveniently by means of a calibrated titanium hydride replenisher[2]. With this arrangement, it was possible to change the pressure by three orders of magnitude in about ten minutes.

At a given frequency, the output circuit was tuned to resonance and the voltage across the tube was noted. Keeping the oscillator output and pressure constant, the measurement was repeated over the available frequency band. Typical results are shown in Fig. 1. The upper curve was obtained by reducing the pressure below 10^{-3} mm. mercury,

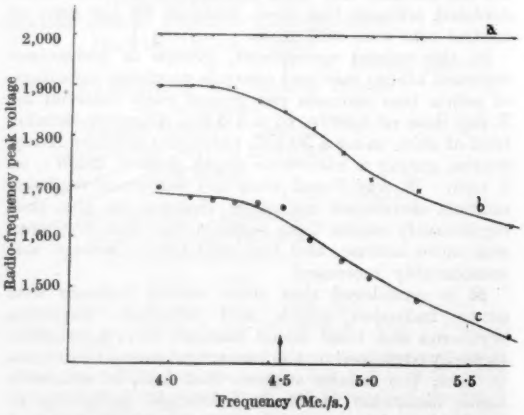

Fig. 1. (*a*) No discharge at pressures less than 10^{-3} mm. of mercury ; (*b*) peak voltage versus frequency at 0·08 mm. of mercury ; (*c*) peak voltage versus frequency at 0·14 mm. of mercury

when no discharge was observed. Taking an average value of magnetic field of 3,000 gauss, the cyclotron frequency for atomic hydrogen is 4·56 Mc./s.

It will be noted that at frequencies below the cyclotron frequency the voltage across the discharge, and hence its impedance, tended to be independent of frequency. Above this frequency there was a progressive decrease in voltage. There was no apparent change in the appearance of the discharge as the frequency was varied. The discharge spread radially to the walls of the tube, but did not completely fill it. The diffusion in the axial direction was much less than in the radial direction. With the present apparatus, one would not expect to observe sharp resonances, because of the highly non-uniform magnetic field in the crossed field regions. It is hoped to continue the work with more refined apparatus. In particular, it would be of interest to observe the effect of shaping the magnetic field in order to reduce the axial diffusion rate.

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Determination of Auroral Height by Radar

It is now well known that excess ionization associated with the aurora in or near the *E*-layer is capable of reflecting very high frequency radio waves with sufficient intensity to be easily detectable on a conventional radar display. Various estimates have been made of the height of the reflecting region, but these have all been obtained indirectly. Currie, Forsyth and Vawter[1], using radars on two frequencies with different lobe-patterns, obtained a most probable height of 108 km. from histograms of echo ranges obtained over a long period. Dyce is quoted[2] as making the assumption that an echo was most likely to be received if the ray from the radar were perpendicular to the Earth's magnetic field line at the echo point. By comparing the probability contours of echo occurrence with contours of various angles of incidence at the echo point, he found a height of about 80 km. for Alaskan observations and around 100 km. for those made at Ithaca. Bullough and Kaiser[3] on one occasion, by assuming that an echoing region observed over a wide arc was at a constant height, estimated a figure of about 120 km.

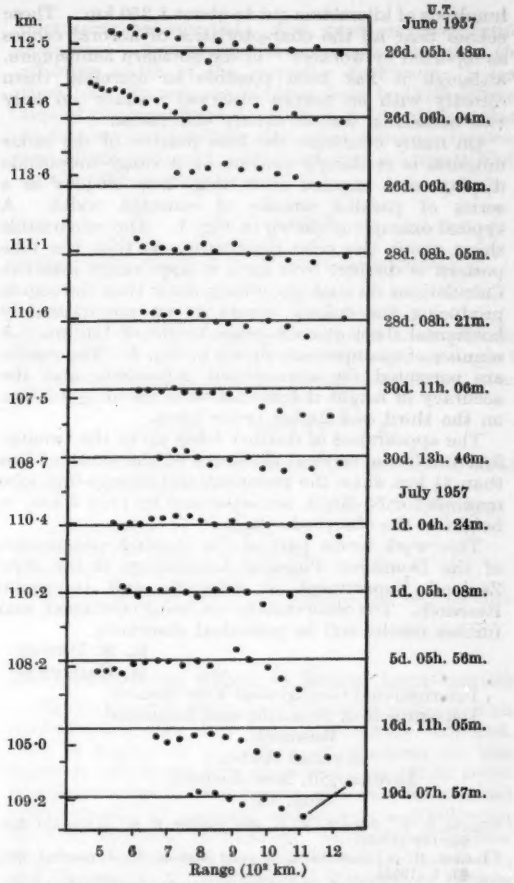

Fig. 2. The observed heights of auroral echoing regions versus observed ranges. The horizontal lines show the 110-km. level, and the separation between them is 20 km. on the scale of height. The figures are average heights in kilometres for each occasion

A radar operating at 55 Mc./s. has recently been established at Bluff, in the South Island of New Zealand, for the observation of auroral radio echoes during the International Geophysical Year. It is situated 850 ft. above sea-level, and a well-defined aerial lobe pattern is obtained by interference of the direct and sea-reflected rays up to an angle of elevation of about 10°. The polarization is horizontal, resulting in deep minima between lobes. The horizontal beam width is 24°. On a number of occasions since the middle of June 1957, while the antenna was pointing in the direction of geomagnetic south, echoes have been recorded over ranges of many

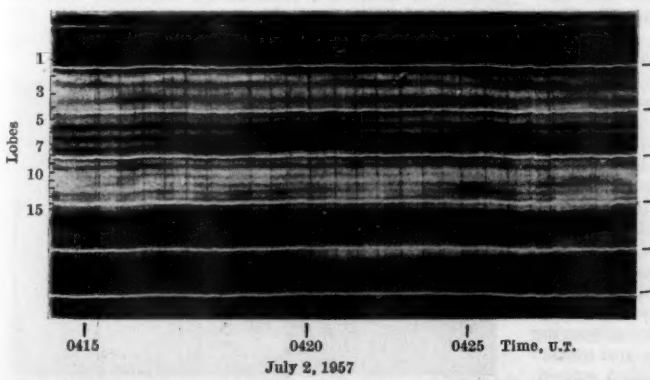

Fig. 1. A range–time record of auroral echoes. The vertical dark lines come from local interference

hundreds of kilometres out to about 1,250 km. These echoes bear all the characteristics of auroral echoes as reported by workers[1-3] in the northern hemisphere, although it has been possible to correlate them directly with an aurora observed visually on only two occasions, due to cloudy conditions.

On many occasions the lobe pattern of the radar antenna is strikingly evident on a range–amplitude display, and appears on a range–time display as a series of parallel streaks of constant width. A typical example is shown in Fig. 1. The remarkable thing about the echo distribution is that the lobe pattern is distinct over such a large range interval. Calculations on such recordings show that the region producing the echoes occurs as an approximately horizontal sheet at an average height of 110 km. A number of examples are shown in Fig. 2. The results are corrected for atmospheric refraction, and the accuracy of height determination is about $\pm 0{\cdot}5$ km. on the third and higher order lobes.

The appearance of distinct lobes up to the twenty-first implies a vertical thickness of the sheet of less than $2\frac{1}{2}$ km. since the twentieth and twenty-first lobe maxima for 55 Mc./s. are separated by only 5 km. in height at the observed range.

This work forms part of the research programme of the Dominion Physical Laboratory of the New Zealand Department of Scientific and Industrial Research. The observations are being continued, and further results will be published elsewhere.

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Structure of Non-porous Anodic Films on Aluminium

It is generally assumed that non-porous oxide films formed on valve metals by anodic oxidation in aqueous electrolytes are normally substantially uniform in thickness and composition. By means of optical and electron microscopy and by preferential chemical dissolution, it has been found that this assumption is definitely incorrect for anodic films formed on aluminium. The non-porous oxide films formed when aluminium is polarized anodically at either constant current or constant voltage in a variety of aqueous electrolytes (for example, borates, carbonates, tartrates and phosphates) at room temperature have a pronounced cell type of structure. A modified form of this cell structure has already been reported in porous aluminium oxide films[1].

The surface of the non-porous anodic films at both the electrolyte-oxide and metal-oxide interfaces is covered with raised domes, which in the latter case correspond with craters on the metal surface. The electron micrograph (Fig. 1) is a replica of the aluminium substrate and shows the craters in the metal. Owing to interaction between neighbouring features, the cross-sections of both domes and craters tend to become irregular polygons. Within experimental error of counting as many craters are found

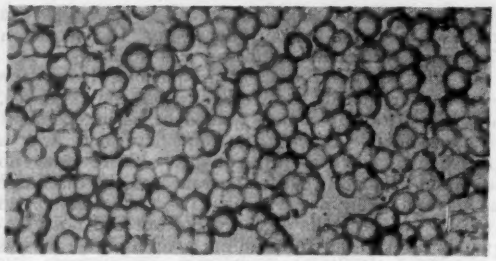

Fig. 1. Electron micrograph of metal surface of 99·99 per cent aluminium formed at 500 V. in 3 per cent boric acid + 0·05 per cent borax at 20° C. Oxide replica. Unshadowed. × *c.* 2,860

on the metal surface as domes on the metal-oxide and oxide-electrolyte interfaces (for example, $1{\cdot}4 \times 10^8$ per sq. cm. for films formed at 500 V. and at 20° C.). It has not been possible yet to show directly that the raised areas at the oxide-electrolyte interface are above the corresponding craters on the metal surface, but it can be deduced that this must be so. Thus the structure of the anodic film tends towards that shown in Fig. 2. The average radius of the cells is proportional to the voltage and is approximately equal to the average thickness of the oxide. As the whole surface is covered with cells, the number of cells must decrease as the formation voltage increases. The number and size of the cells appear to be independent of the grain orientation of the underlying metal.

As the thickness of the anodic film is not uniform, it must be easier for the oxide to grow at some points of the film than at others. This indicates that the layer may not be of uniform composition and this has been confirmed. Altenpohl[2] has reported that when anodic alumina films are treated with a hot chromic acid–phosphoric acid solution, part of the oxide dissolves rapidly and part is insoluble. It has now been found that the soluble portion occurs in a central column through the cells and the insoluble in the region of the junction between the cells, that is, the areas where the oxide layer is thinnest. The insoluble material gives sharp electron diffraction patterns and appears to be crystalline γ' alumina and it is believed that the soluble portion is practically amorphous.

As the temperature of formation is increased, the amount of insoluble crystalline oxide increases considerably. Since such material opposes the radial growth of the cells, it is to be expected that the pattern of cells formed at temperatures near the boiling point of the electrolyte will be less perfect

Fig. 2. Idealized structure of anodic alumina films

than those formed at low temperatures. This is found to be the case, although the basic cellular structure, however indistinct, is always detectable.

It is apparent that this type of construction of the oxide layer can explain the growth of porous films on aluminium. If formation is carried out in an electrolyte capable of dissolving the central column of the cells, growth of the oxide can continue, and a structure such as that found by Keller *et al.*[1] will result.

Anodic oxide films formed on tantalum, niobium and zirconium have not been found to exhibit similar structures, but films formed on zirconium are distinctly non-uniform in thickness.

I would like to thank D. J. Stirland, B. Nightingale and R. Bicknell for assistance in carrying out some of the experimental investigations.

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Detection of Particles inside Potential Barriers

There appears to be some uncertainty regarding the interpretation of wave functions in classically inaccessible regions, where the total energy is less than the potential energy. The following question is asked often: Can one detect a particle inside a barrier without giving it enough energy to be, classically, in the region of localization?

It can be argued quite generally that one cannot. Localization is a transition to a state represented by a wave packet, construction of a packet requires oscillating functions, and oscillating functions imply real momenta and positive kinetic energies[1]. It is the purpose of this communication to present a thought experiment that illustrates this situation.

Consider a step function potential, with $V = 0$ for $x < 0$, and $V = V_0 > E$, the energy of the state, for $x \geqslant 0$. The wave function for $x \geqslant 0$ is then $\exp(-\alpha x)$, where

$$\alpha = \sqrt{2m\,(V_0 - E)}/\hbar$$

Let us consider localization of a particle by having it scatter a photon inside the barrier. We ask whether such localization is possible without a transfer of energy greater than $V_0 - E$ to the particle. One might think that one can go far into the barrier and use arbitrarily long wave-length, low-energy photons. Such a procedure will be shown to be unsuccessful.

Suppose that $I(x)$ is the intensity of photons travelling along the y direction at x, and that $I(x)$ has a maximum somewhere in the barrier. Let there be a collimating system and detector arranged to observe photons scattered through an angle θ. If a scattered photon is observed, the probability, $P(x)$, of it having been scattered at x is proportional to $I(x)$ times the probability of a particle being at x:

$$P(x) \sim I(x)\,\psi^*(x)\,\psi(x) \sim I(x)\exp(-2\alpha x)$$

If we are to claim detection inside the barrier, $P(x)$ must increase as x increases from zero. Therefore $I(x)$ must increase rapidly enough to overpower the decreasing exponential; $I(x)$ must increase faster than $\exp(+2\alpha x)$ toward its maximum. But then the effective width of the intensity distribution is less than $1/\alpha$. We now require that there be little diffraction of photons through an angle θ into the counter, so that we can conclude that most photons observed are indeed scattered. We have then an upper limit on the photon wave-length:

$$\lambda < \frac{1}{\alpha}\sin\theta$$

and a lower limit on the photon momentum:

$$p > h\alpha/\sin\theta$$

But then the momentum transferred to a particle that scatters one of the photons through an angle θ is no less than $h\alpha$, and the energy transferred is no less than

$$(h\alpha)^2/2m = (2\pi)^2\,(V_0 - E)$$

or more than enough to permit the particle to exist in the region $x \geqslant 0$.

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An Unexpected Effect in Sound Localization

While sound localization by human subjects with unobstructed ears has been extensively explored, little is known of the effects of headgear on this function. Evidence from unpublished work on arctic headwear suggests that localization may be affected independently of threshold sensitivity; and following work on the Army 'combat cap' which failed to show any threshold changes due to the cap (Holding, D. H., and Dennis, J. P., unpublished Ministry of Supply Report, 1955), it was decided to investigate the effect of wearing the cap on the localization of pure 1,000 c./s. tones.

The cap is of light wind-resistant cloth, with ear-flaps loosely secured by a chinstrap. Sixteen subjects, eight research workers and eight soldiers, were each required to localize 128 stimuli of 0·5-sec. duration, at a sound-level of 25 db. (above 0·0002 dyne/cm.^{2}) at the subjects' head, with and without the combat cap. The 2,048 sound stimuli were presented in groups of sixteen stimuli in random order. The stimuli originated from four loudspeakers equidistant from the subject, in eight positions relative to the subject, whose seat was rotated 0°, 45°, 180° and 225°, in order to obviate experimental artefacts due to any acoustic irregularities of the speakers or of the fatigue laboratory in which the experiment was conducted. Localization was by forced-choice among the speakers, which were identified by numbers. A record was also kept of response times.

After transformation of the data by $\sin^{-1}\sqrt{x/n}$, analysis of variance of correct and incorrect responses showed a significant ($P < 0{\cdot}01$) difference between cap and no cap, in favour of wearing the cap. The effect due to the cap interacted with the direction of sound source relative to the subject, the bulk of the improvement lying in the off-front area.

Fig. 1 is a graphical representation of the distribution of correct responses for both cap and no cap

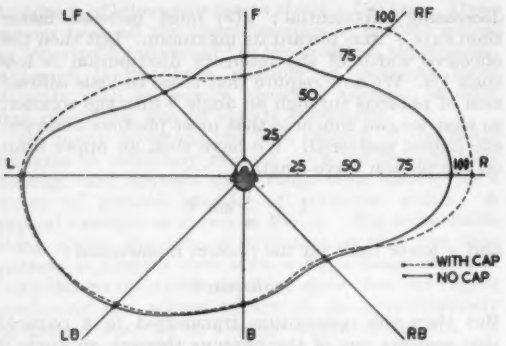

Fig. 1. Effective localization field. (Distance from centre represents number of correct responses.) (Reproduced by permission of H.M.S.O. Crown copyright reserved)

conditions. As in previous work, subjects showed more confusion between front (F) and back (B), than from side to side (R and L). Rotation of 0° and 180° relative to the first loudspeaker was more effective than rotation of 45° and 225°. Response times did not discriminate between cap and no cap, but correct responses took significantly ($P < 0.001$) shorter times than incorrect responses.

The unexpected improvement due to wearing the cap may be due to phase differences, which are more important than intensity difference below about 2,000 c./s. The wave-length of a 1,000-c./s. tone is of the same order of magnitude as the human head, and the topography of the cap presents an asymmetrical obstruction to sounds from the left and right front areas.

We wish to acknowledge the assistance of Mr. J. Draper in making the statistical analyses.

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Ionophoretic and Chromatographic Analysis of Single Dust Particles

It may sometimes be an advantage to analyse chemically single dust particles occurring with many others of different composition. Minor constituent particles would then be revealed undiluted by the others, and individual variations not obscured. For similar reasons such an analysis might also find other applications in chemical and biological fields.

A few workers have adapted microchemical spot tests to examine individual particles in atmospheric dust[1], 'smog' and fog[2], and air pollution[3]; but otherwise relatively little work appears to have been done in this direction.

A microscopic ionophoretic and chromatographic method has been developed[4] which is carried out in very thin liquid films on clean glass surfaces in a humid chamber. The resolved zones are detected by the 'breath figure' test usually observed interferometrically. Atmospheric dust rapidly contaminates

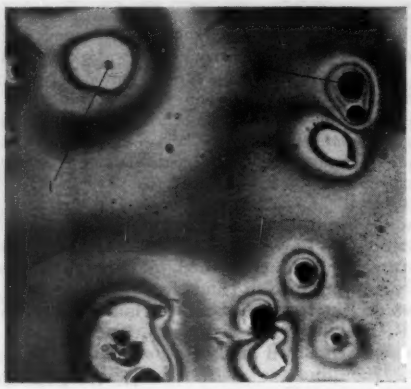

Fig. 1. 'Breath figure' of atmospheric dust particles on a clean glass surface: 1, with central hydrophobic 'halo' surrounded by a hydrophilic 'halo'; 2, condensation on hydrophilic particle. Reflexion interferometry, white light. (× 30)

the surfaces if turned upwards. Since 1·4–4·0 mμgm. has been estimated quantitatively by this method, and the weight of many dust particles falls within its range, it might be possible to analyse them in this way.

A single dust particle forms a 'halo' of contamination up to 1 mm. or more in diameter, which may be hydrophobic or hydrophilic according to the composition of the particle and its solubility in the film (Fig. 1). Contrast can sometimes be intensified by warming or by using ammonia vapour, etc., as 'reagents' corresponding to colour-producing reagents. Thick capillary condensation on insoluble dust specks also occurs, and submicroscopic particles can be revealed by this and by halo formation (see also refs. 3, 5).

Halos can be developed further in two ways. They can be enlarged by condensing a 0·1–10μ thick acid or water film on the surface, allowing to stand for 1–10 min. inside the humid chamber, neutralizing with ammonia if necessary, and drying. Concentric rings may be formed (Fig. 2) corresponding to circular chromatographic development on filter paper, and this can be increased further by repeatedly condensing and evaporating the film. In the course of routine separations with this method, accidental dust contamination is sometimes also found to elongate in the direction of film flow, and in a number of cases zones have been observed.

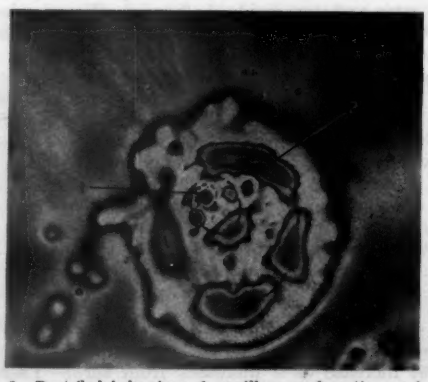

Fig. 2. Dust 'halo' showing: 1, capillary condensation on dust particle; 2, circular development. (× 56)

It should be possible to identify unknown particles by running at the same time as dusts of known composition or standard chemical mixtures. Halo or zone areas might then be taken as a measure of quantity, and the weight of completely dissolved particles calculated. The method might also be suitable for studying radioactive dusts in combination with autoradiography.

My thanks are due to Dr. J. Stern, of the Fountain Hospital, London, S.W.17, for advice, and to Mrs. A. Turner for assistance in preparing the manuscript.

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Chromatography by Liquid–Liquid Partition and Liquid–Liquid Interface Adsorption

For liquid–liquid partition chromatography with columns a linear relationship exists between the logarithms of corrected retention volumes (R_t) of terms of homologous series and the order n of these terms[1].

Thus: $$\log R_t \sim \text{lin } n \qquad (1)$$

where R_t is defined as the retention volume minus the volume of the mobile phase in the column itself. However, the experimental verification of equation (1) often encounters difficulties in which the carriers of the immobile phases seem to be involved.

An extensive investigation has been carried out in order to gain an insight into the nature of these deviations from ideality. Homologous series of coloured derivatives of aliphatic alcohols, aldehydes, ketones, acids, amines, mercaptans and alkyl halides were used. In these derivatives the occurrence of acid, basic, ionogenic or OH-groups was avoided. Light petroleum, alone or mixed with carbon tetrachloride or benzene, was used as the non-polar phase. A number of polar solvents, including nitromethane, NN′-dimethylformamide, formamide, acetonitrile, 'Methylcellosolve', methanol, propylene glycol, either alone or mixed with each other or with small percentages of water, were used as polar phases. Silica gels were prepared according to Gordon, Martin and Synge (*G*-gels) or to Nykamp (*N*-gels), and served as carriers of the immobile phases[2].

It was observed that the amount of loading of the gels with immobile phases relative to their maximum capacity was of the highest importance with respect to the nature of the phenomena. If the gels were loaded over a certain limit, equation (1) was invariably obeyed. Under these conditions all aliphatic series tested could be separated and the individual terms identified by a multitude of variants, each of which displayed its own merits with regard to sharpness of separation or the range of terms which could be separated efficiently. In this way many isomers could be unravelled too (for example, *cis* and *trans* azo-compounds, and syn- and anti-isomers of 2,4-dinitrophenylhydrazones of *n* aliphatic aldehydes).

Loading the gels with quantities of immobile phases less than the limit indicated above resulted in the simultaneous operation of liquid–liquid partition and liquid–liquid interface adsorption. The participation of the latter is clearly demonstrated by experiments with the *N*-gels of high capacity (maximum capacity ± 3 ml./gm.). Loading these gels to less than ± 2 ml./gm. resulted in increased adsorption. This adsorption, occurring in a loading range where the immobile phase is still in excess of the weight of the carrier itself, should be interpreted as liquid–liquid interface adsorption, and its importance in this region is due to the great extension of these interfaces. This view could be confirmed by eliminating the liquid–liquid partition mechanism by using water as the immobile phase. Loading the *N*- and *G*-gels below the level of ideal behaviour invariably resulted in a certain retention of the coloured bands.

This liquid–liquid interface adsorption could be exploited as an independent tool for chromatographic separations. On the interface between light petroleum and water the azo-isomers, as well as the dinitrophenylhydrazone isomers, could be resolved.

This variant of chromatography, which is applicable in a reversed-phase form as well, can be carried out in a very simple way and seems particularly suitable for the separation of labile substances because of its mild conditions and uniformity of the adsorption surfaces.

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Group Localization Energy and Polarographic Half-Wave Potentials of Aromatic Nitro Compounds

In a number of publications[1,2] it has been established that the reduction potential of aromatic compounds may be correlated with the π-electron energy change associated with the localization of electron or electrons at different positions of the molecule. Thus in the reduction of quinones the electron-localization took place at the two oxygen atoms, while in the case of aromatic hydrocarbons they were localized at the two *p*-carbon atoms. In the case of more complex compounds the localization may take place at certain groups of atoms undergoing reduction.

It is now fairly well established that aromatic nitro compounds undergo reduction at a dropping mercury electrode by a four-electron four-proton addition step and in the acid region one sharp polarographic wave is obtained. The process may be represented as:

$$C_6H_5NO_2 + 4e^- + 4H^+ \rightarrow C_6H_5NHOH + H_2O$$

We suggest that the reduction potential should be proportional to the π-electron energy difference between the parent compound and the transition state with four electrons localized on the nitro group. This energy difference may be calculated by the linear combination of atomic orbitals method if we assume that the energy of four electrons localized

Table 1. Group Localization Energy and Half-wave Potentials

Compounds	$(\Delta\pi + \varepsilon)/\beta$	$E_{1/2}$ (volts) referred to standard calomel electrode (ref. 4)
p-Nitrophenol	10·381	0·35
Nitrobenzene	10·230	0·28
p-Nitrobenzoic acid	10·166	0·17
p-Dinitrobenzene	9·934	0·00
p-Nitrobenzaldehyde	10·133	0·24

on the nitro group is equal to $4\alpha_c + \varepsilon$, where α_c is the coulomb integral for carbon and ε depends on the electro-negativities of the oxygen and the nitrogen atoms in the nitro group. We have calculated this energy difference using for the coulomb and resonance (β) parameters of the hetero-atoms in a number of nitro compounds, values given by Orgel *et al.*[3], with the only exception that for N+ we have used the value 1 instead of 2 for the coulomb integral. In Table 1 are summarized the values of the π-electron energy difference ($\Delta\pi$) in such group localization, together with the half-wave potentials of a number of aromatic nitro compounds.

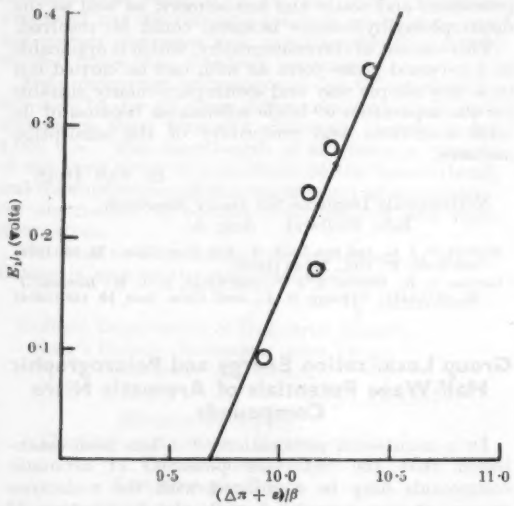

Fig. 1

The $E_{1/2}$ values refer to the medium of *p*H 2. At higher *p*H, the $E_{1/2}$ increases for all the compounds, which means that the process is dependent on hydrogen ion concentration, as it should be if the reaction is represented by the equation (1). On the other hand, if we accept Maccoll's suggestion that $E_{1/2}$ is proportional to the energy of the lowest unfilled molecular orbital or orbitals, then it should be independent of *p*H. A fairly linear plot of $(\Delta\pi + \varepsilon)/\beta$ vs. $E_{1/2}$ (Fig. 1) seems to lend further support to our group localization hypothesis.

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Effect of Storage of Methylcellulose on Blood Protein Formation in the Rat

In previous experiments a considerable storage of the methyl–ether of cellulose was observed in the reticulo-endothelial system[1]. As this system plays an important part in protein formation, it was assumed that a change in serum proteins takes place following its administration.

70 male albino rats were injected intraperitoneally with 1 ml. 2·5 per cent methylcellulose (mol. wt. 82,000) dissolved in water twice weekly for five weeks, and the resulting changes in serum proteins were examined by paper and free electrophoresis (Antweiler equipment), directly before administration, and after the last injection.

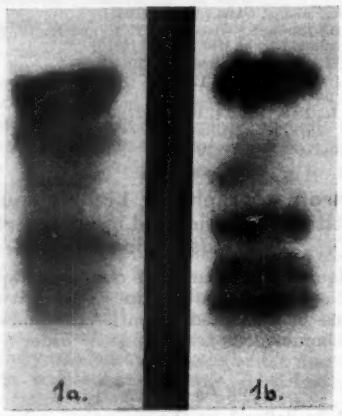

Fig. 1. Paper electrophoretic pattern of rat, 1*a*, before, 1*b*, after, methylcellulose treatment

The results of paper electrophoresis show clearly the presence of a new component in the γ-globulin region, only faintly visible in the electrophoretogram of the untreated animal (Fig. 1). The quantitative results prove the significant diminution of total protein following the administration of methylcellulose by a further decrease in albumin and α- and β-globulins. The γ-globulin, determined together with the new fraction increased significantly.

Investigated by free-electrophoresis the γ-globulin resolved itself into two fractions (Fig. 2). The electrophoretic pattern of rat sera treated with methyl-

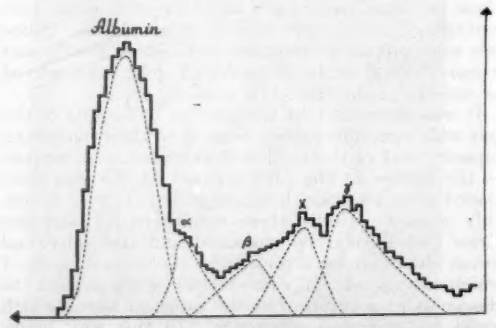

Fig. 2. Free electrophoretic pattern of rat treated with methylcellulose

cellulose is similar to those changes following hyper-immunization of horses with diphtheria toxin[2]. As a result of this observation, the antigenic properties of methylcellulose itself were investigated by the immune precipitation method. If sera of an animal treated with methylcellulose were added to methylcellulose itself, precipitation occurred, but not in the case of normal sera. This result suggests that methylcellulose is a substance possessing antigenic properties. Results of agar gel diffusion experiments confirmed those obtained by electrophoresis: the increase of one and decrease of two antigenic components was also observed by this method.

Details and discussion of this problem will be published in another paper.

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The Glass Scratch Effect and Molecular Structure

A CLOSE relation exists between the effect of scratching the wall of a glass container with the tip of a glass rod and the nature of the liquid present. Ordinary round-bottomed 5-ml. test tubes are half filled and the inside wall briskly scratched some fifty times. The result is examined under proper light, the contents stirred, allowed to settle overnight, and the sediment examined. Three types of effect are observed. (1) The rod slips. This is caused by aromatic compounds (except benzene and some simpler derivatives); some other cyclic compounds; open-chain compounds of more than ten carbons approximately. (2) The rod bites and produces glass dust, varying in amount and texture, which immediately disperses. This is caused by non-polar compounds of low weight, most ketones, and sulphuric acid. (3) The rod bites and produces abundant dust which sticks most characteristically to the wall, on which it can be smeared. This is given, in decreasing order, by: (*a*) water and monohydroxyalcohols; (*b*) dihydroxy-alcohols, primary amines; (*c*) aliphatic acids, some esters, aldehydes, ketones, secondary amines. This last group is intermediate between (2) and (3).

After sedimentation, the dust yields two typical patterns, with intermediate stages, namely, an even deposit over the whole bottom of the tube, characteristic of aggregated particles, produced by most substances; or a small pellet at the very tip, characteristic of non-aggregated particles, produced only by polar compounds of low weight.

The results are easily reproduced, the only difficulty arising from highly refractile liquids, which make the dust poorly visible. The kind of glass is immaterial. The dust consists mostly of particles 1–2μ in diameter, in intense Brownian motion when of type (3). The effect in water is much decreased by electrolytes, unaffected by non-electrolytes. Solid organic compounds sufficiently soluble in non-polar solvents can also be tested, with comparable results.

It is obvious that class (1) compounds possess molecules of such size or shape, or linked in such a way, as to prevent contact between glass surfaces; classes (2) and (3) do the opposite, the peculiar effect of the latter being due, presumably, to the affinity of 'active' hydrogen for glass[1]. Some occasionally unexpected observations follow. Diacetyl (the structure of which is discussed in ref. 2) gave a slip in spite of its low weight and open chain. Benzoic acid in ether, in which it is linked to the solvent, gave a slip in much lower concentration than in chloroform, in which it forms dimers[3]. The lower alcohols up to butyl were indistinguishable; among the amyl, however, the primary ones were clearly more reactive.

Some findings must be interpreted as manifestations of spontaneous enolization, such as the smear given by some ketones[4], aldehydes, acetic anhydride, contrary to conventional formulæ. The same effect was induced in acetone by 1 per cent ferric chloride (which has been found by Meyer[5] to increase the enol fraction of aceto-acetic ester). Acetylacetone resembled class (1) substances, presumably because of internal hydrogen bonding; acetonylacetone reacted like an OH-compound, in agreement with its newer formula[6]. Finally, mixtures of compounds in varying proportions occasionally offered challenging pictures, such as non-aggregation zones in ethyl ether–chloroform (cf. ref. 7).

In mixtures the effect is seldom additive, in the sense that it does not usually give the expected sum of the effects of single components, but reflects the existence of complexes, or, more generally, physical interaction between molecular species. This manifests itself in slippery zones (for example, in the systems water/sulphuric acid[8], ethyl ether/sulphuric acid[9], acetone/carbon disulphide), which indicate the formation of molecular aggregates; in the unexpected appearance of non-aggregation (4 per cent methanol, or a trace of sulphuric acid, in ether); in the sudden passage of aggregation to non-aggregation (in water–acetone, as soon as the mole ratio exceeds 4 : 1, the point of maximum contraction[10]); in the appearance of the smear type of reaction, in compounds with an ether bond, under the influence of some salts, such as ferric chloride. An outstanding feature of the effect is its considerable variety.

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Prevention of Reversal in Mercury-198 Lamps

The green emission line 5461 A. of mercury-198 has been proposed by Meggers[1] as a primary standard of wave-length, and is one of the lines being considered as the basis for a redefined international metre. The line has much to recommend it in its sharpness, isolation from other lines, convenience of excitation, etc.

However, as the line is excited at present in an electrodeless lamp with argon as a carrier gas, there is the serious disadvantage that it very easily suffers reversal which is unsymmetrical, thereby becoming broadened and shifted in wave-length. As a consequence the lamp must be operated and observed very carefully. The temperature must be maintained below about 10° C., although the intensity of the line is reduced and the lamp will not operate at much below 0° C.

To overcome this difficulty an attempt has been made to use the well-known property of molecular gases of reducing the tendency to reversal by depopulation of metastable levels[2]. Lamps have been made and observed which contain as carrier gases respectively hydrogen, nitrogen and mixtures of these gases with argon.

The results are illustrated by Fig. 1. At the right is seen the profile of the 5461 A. mercury-198 line emitted by a small electrodeless argon-filled lamp run in air without special cooling and viewed end on; at the left is the profile of the same line excited and viewed under identical conditions except that the carrier gas was nitrogen instead of argon. A similar improvement was found with hydrogen. In both cases the intensity at peak was considerably enhanced. The argon–hydrogen and argon–nitrogen mixtures showed improvement which was somewhat less but nevertheless great; on the other hand the excitation of the mercury lines compared with the background due to nitrogen and hydrogen was somewhat better with the mixtures.

The wave-length shift due to the presence of nitrogen was measured and found to be less than for argon[3]; that due to hydrogen would also be expected to be small on the basis of measurements made at high pressure[4]. The nitrogen tends to form Hg_3N_2 which, however, under the discharge conditions is in equilibrium with N_2 at sufficient pressure for useful operation of the lamp.

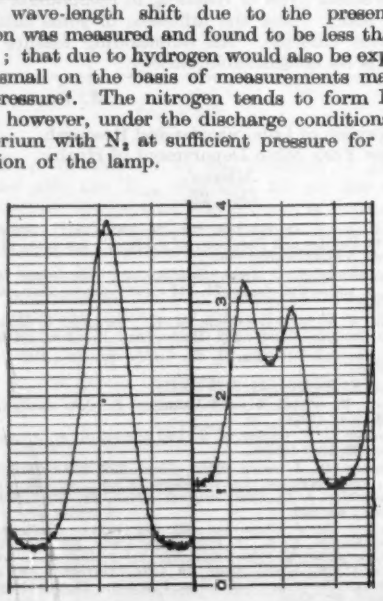

Fig. 1

So far as the experiments have gone it appears that the usefulness of the mercury-198 green line as a standard or for length measurement would be greatly increased by the method of preventing reversal described. A study of such matters as the life of the lamp, the importance of the slight background, the exact wave-length emitted, etc., is in progress.

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Unloading Effects in Copper Single Crystals

Haasen and Kelly[1] have observed a small yield point on retesting previously strained single crystals of aluminium and nickel at the same or lower temperatures than the initial deformation. The effect occurred only when the crystals were unloaded between tests, and no yield point was found at low stresses. Annealing at 300° K., between tests at 90° K., increased the magnitude of the yield phenomenon and much larger yield points were observed when the second deformation was carried out at a lower temperature than the first. Haasen and Kelly attributed the effect to the rearrangement of dislocations during unloading.

The present work was undertaken to investigate further the phenomenon in copper single crystals, and, in particular, to determine in more detail the effect on the magnitude of the yield point of (*a*) partial unloading and (*b*) annealing between tests.

Single crystals of copper were prepared in a split graphite mould by the Bridgman technique from spectroscopically pure wire. After electropolishing, tensile tests were carried out in a motor-driven hard beam machine at a variety of temperatures between −195° C. and 200° C.

Experiments were first performed in which frequent unloading tests were made at small strain increments during the whole stress–strain curve at various temperatures. The overall shape of the curve was identical with that of specimens tested continuously at the various temperatures; in detail, however, the two curves were different in that a yield point was observed on retesting after unloading during the linear and parabolic hardening regions. The stress–strain curve after the yield point returns to the extrapolation of the curve obtained prior to unloading. No yield points were observed at any temperature on retesting during the easy glide stage of deformation. The magnitude of the yield point was directly proportional to the flow stress and independent of the temperature of testing, a constant value of (stress before unloading/stress on retesting) of 0·986 being obtained between −195° C. and +100° C. There was no dependence of the ratio on the time for which the specimen was unloaded at any temperature. During experiments in which the load was only partially removed a linear relationship was found between the amount of unloading and the ratio of the flow stresses, indicating that the

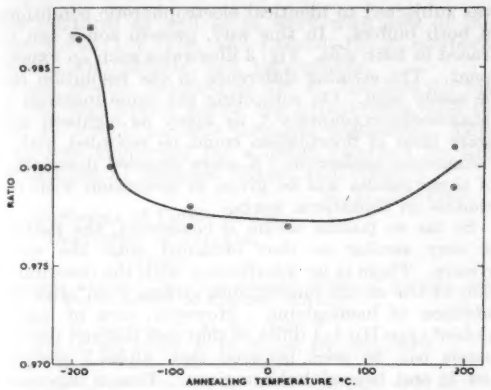

Fig. 1. Average ratio of flow stress before/after unloading at −195° C., after intermediate annealing for 30 min. at various temperatures

size of the yield point is directly governed by the reduction in stress during unloading. A striking feature is that the same linear relationship is obtained at different temperatures between −195° C. and +20° C.

The effect on the size of the yield point of interposing an annealing treatment between unloading and retesting has been examined. The ratio of flow stresses obtained at −195° C. after intermediate ½-hr. annealing treatments at higher temperatures is shown in Fig. 1 and shows a large well-defined drop between −180° C. and −120° C. from 0·986 to 0·977. The shape of the yield phenomenon on retesting at −195° C. is markedly altered by annealing at above −120° C., the yield drop being replaced by a much longer, almost horizontal region in the stress–strain curve. The amount of unloading has no significant effect on the size of the yield phenomenon after annealing at above −120° C.

The unusual nature of the experimental results suggests that the effect is due to a dislocation–dislocation interaction, and the absence of the effect during easy glide suggests that it is associated with the motion of dislocations on intersecting slip planes. A basic problem facing all theories of work hardening is to explain why the large numbers of dislocations piled against barriers during the deformation do not relax completely when the applied stress is removed, giving large reverse plastic flow. Obviously some locking process occurs during unloading which prevents the large-scale running back of dislocations under the back stress and it is probable that it is this locking process which is responsible for the yield point on retesting. Experimental evidence indicates that the size of slip line formed during the linear hardening region is much too large for all possible

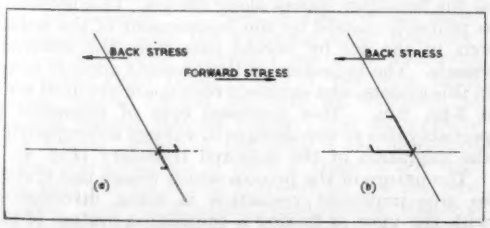

Fig. 2. Sessile dislocation formed on unloading with apex (*a*) in the direction of the back stress and (*b*) in the direction of the forward stress

Lomer–Cottrell sessile dislocations to have been formed during the deformation, as is required by Friedel's[2] theory of linear work-hardening, and the possibility exists, therefore, of the formation under the back stress of new sessile dislocations during unloading. These prevent the remaining dislocations in the active system from running back, so that large reverse plasticity cannot occur. Energy is released during the formation of the new sessile dislocations[3] and hence a larger stress is required to dissociate them.

The increased effect obtained at −195° C. after annealing between tests at above −120° C. may be due to the thermally activated reversal of the apices of the new sessile dislocations. Stroh[3] has shown that, in copper, Lomer–Cottrell sessile dislocations break up only by dissociation and that this process occurs more easily if the apex of the sessile points in the opposite direction to the stress. During unloading at −195° C. sessile dislocations are formed in position (*a*), Fig. 2. Suppose that, on annealing at between −180° C. and −120° C., sufficient thermal energy is available for reversal to occur to position (*b*) under the back stress. On retesting at −195° C. dissociation can occur only from position (*a*) and hence sufficient stress must be applied to reverse the sessile without assistance from thermal fluctuations and consequently a large yield effect is obtained. If the whole experiment is carried out at −195° C. no reversal occurs on unloading, and hence on retesting the sessile is already in position (*a*) and a high ratio, 0·986, is obtained. During tests at above −120° C. the sessile changes from position (*a*) to (*b*) under thermal activation during unloading and similarly easy reversal occurs on retesting, so that dissociation again occurs with a high ratio of flow stresses, 0·986.

A full account of these experiments is being published elsewhere.

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Starch Gel Electrophoresis in a Discontinuous System of Buffers

The recently developed starch gel electrophoresis has proved to have a resolving power superior to any other type of zone electrophoresis[1–4]. I have applied this technique to the study of highly purified toxins[3], but further work on the separated and eluted fractions of the toxin of *Corynebacterium diphtheriae* in tissue cultures and in animals indicated that the resolution of these proteins was not completely satisfactory in the buffer (0·03 *M* boric acid and 0·012 *M* sodium hydroxide) normally used in this type of zone electrophoresis. A more suitable system was found with a mixture of *tris*-(hydroxymethyl)-aminomethane-citrate (*tris*-citrate) used in conjunction with a boric acid buffer. Preliminary results obtained with toxins, enzymes and human sera are briefly reported here.

The gels are made from a buffer containing 0·076 *M* *tris*-(hydroxymethyl)-aminomethane (Sigma 121) and 0·005 *M* citric acid (*p*H 8·65). These gels

Fig. 1. Concentrated crude diphtheria toxin (staining with amido black 10*B*) subjected to electrophoresis for 3 hr. at a potential gradient of 6 V./cm.; (*a*) in sodium hydroxide/boric acid buffer; (*b*) in *tris*-citrate buffer

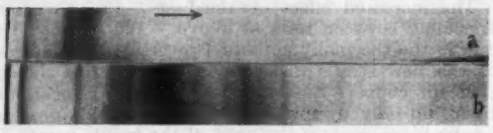

Fig. 2. Horse radish peroxidase (stained with benzidine–hydrogen peroxide reagent) subjected to electrophoresis for 3 hr. at a potential gradient of 6 V./cm.; (*a*) in sodium hydroxide/boric acid buffer; (*b*) in *tris*-citrate buffer

are used as a discontinuous buffer system with 0·3 *M* boric acid and 0·05 *M* sodium hydroxide in the electrode vessels. A markedly better separation of the materials tested was obtained with this discontinuous system than in either the usual continuous sodium hydroxide/boric acid buffer system or in a continuous system using the *tris*-citrate acid buffer. Figs. 1*a* and 1*b* represent the patterns obtained with crude diphtheria toxin when subjected to electrophoresis by the two systems. Figs. 2*a* and 2*b* show the results with horse radish peroxidase (Nutritional Biochemicals Corp., Cleveland, Ohio).

In order to relate the new components to those previously separated and thus to determine their origin, the toxin was subjected to electrophoresis in a gel prepared in the following manner: a large tray was first filled with a starch prepared in the *tris*-citrate buffer and allowed to solidify. One-half of this gel was cut out and in its place starch prepared with the usual buffer was poured and allowed to solidify. Then a filter paper soaked in the toxin was applied across the gel so that the same material

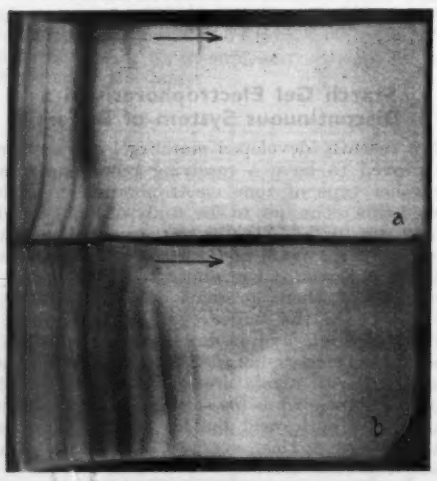

Fig. 3. Concentrated crude diphtheria toxin (staining with amido black 10*B*) subjected simultaneously to electrophoresis for 3 hr. at a potential gradient of 6 V./cm. in (*a*) sodium hydroxide/boric acid buffer; in (*b*) *tris*-citrate buffer

was subjected to identical electrophoretic conditions in both buffers. In this way, protein zones can be traced in both gels. Fig. 3 illustrates such an experiment. The striking difference in the resolution can be easily seen. On subjecting the same material to immunoelectrophoresis[3,5], as many as eighteen separate lines of flocculation could be recorded with a commercial antiserum. A more detailed description of these results will be given in connexion with the studies on diphtheria toxin.

So far as human serum is concerned, the pattern is very similar to that obtained with the usual system. There is no interference with the determination of the serum haptoglobin groups even after the addition of hæmoglobin. However, sera of haptoglobin[6] type Hp 1–1 differ in that new distinct protein bands can be seen between slow alpha-2 globulin (*S*α-2) and beta-globulin regions. This is especially true in the case of the newborn. The gamma globulins migrating backwards stain less intensely in the new buffer system. Studies with the aid of two-dimensional electrophoresis and immunoelectrophoresis are in progress to establish the origin of the new zones.

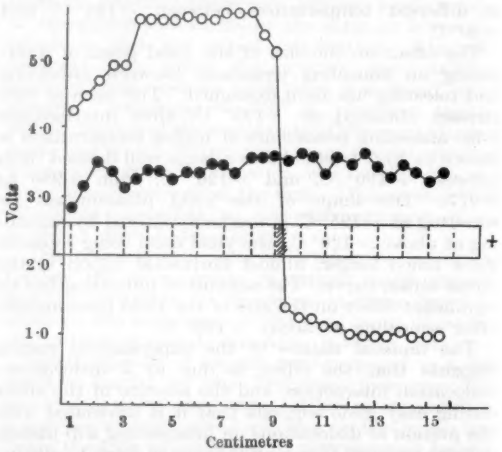

Fig. 4. Potential gradients measured with a vacuum tube voltmeter at 0·5-cm. intervals along the gels at the same time, without any material applied. Full circles (—●—●—●—) represent the mean potential gradients between the adjacent electrode-pairs in sodium hydroxide/boric acid buffer. The open circles (—○—○—○—) show the potential gradients in *tris*-citrate buffer. The cross-hatched area represents the position of the coloured band at the time of measurements

It must be pointed out that a visible boundary moves through the gel towards the cathode at a rate of about 1 cm./hr. at a gradient of 6 V./cm. This boundary is visible because a brown-coloured material accumulates at it which increases in intensity as the boundary moves along the gel. This boundary is probably caused by the replacement of the citrate ions in the gel by borate ions from the electrode vessels. The migration of the proteins appears faster in this system, and excellent results are obtained after a 3-hr. run. This increased rate of migration is probably due to the changes in voltage accompanying the migration of the coloured boundary (Fig. 4).

The nature of the process which causes this system to give improved resolution is being investigated with the view of finding a continuous system of the same resolving power. I feel that this system has definite application in work with very complex pro-

tein mixtures as well as in work with sera of the haptoglobin 1–1 type, and particularly in newborn infants, who usually lack haptoglobin.

I am greatly indebted to Dr. O. Smithies for his interest and advice during the experiments, and to Mrs. E. Poulik for able technical assistance. This work was supported by a grant awarded by the Department of National Health and Welfare.

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Chlorogenic Acid Metabolism in Cider Fermentation

CHLOROGENIC ACID is invariably found in cider-apple juices[1], and our unpublished results show that in some varieties it may constitute more than 0·25 per cent (w/v) of the juice. Paper chromatographic examination of a number of ciders showed that chlorogenic acid frequently disappeared during fermentation. Where caffeic acid was present in the original juice, this acid also disappeared, and these changes occurred only in ciders which showed reduction of quinic acid to dihydroshikimic acid. It seemed likely that chlorogenic and caffeic acids were metabolized by the *Lactobacillus* found capable of reducing quinic acid to dihydroshikimic acid, namely, *L. pastorianus* var. *quinicus*[2,3].

Work with partially disintegrated cells of this strain indicated that the first stage in the metabolism of chlorogenic acid was hydrolysis to caffeic and quinic acids. Both products were further metabolized, and the metabolism of caffeic acid was investigated by the use of growing cells. A pure culture of the same organism was inoculated into a basal medium[2] with the addition of 0·025 per cent caffeic acid. After 7 days incubation at 25° C. under conditions of reduced oxygen tension, the caffeic acid was completely metabolized. In a control flask, to which killed organisms were added, the caffeic acid remained unchanged. Quantitative oxidation with potassium permanganate of the uninoculated and inoculated media after incubation suggested saturation of the caffeic acid side-chain[4]. Paper chromatographic examination showed that two main products *A* and *B* were present; they were extracted with ether after acidification of the medium and were separated on a silica gel column. *A* and *B* reacted on paper chromatograms with the following spray reagents: (1) 1 per cent ferric chloride–1 per cent potassium ferricyanide (blue colour); (2) 1 per cent ferric chloride (green colour) followed by exposure to ammonia vapour (purple colour); (3) ammoniacal silver nitrate (black in the cold); (4) diazotized *p*-nitraniline (orange). *A* gave a violet colour with 1 per cent sodium borate followed by 0·4 per cent ethanolic 2 : 6 dichloroquinonechlorimide while *B* gave a maroon colour; *A* was acidic to bromocresol green while *B* at the same concentration was not detectable with this indicator.

Reactions (2) and (3) suggested that both *A* and *B* were compounds of the catechol type. *A* had the same R_F values as dihydrocaffeic acid in 2 per cent acetic acid[5] and in benzyl alcohol–*iso*-propyl alcohol – tert.-butyl alcohol – water – formic acid (3 : 1 : 1 : 1 : 2 per cent)[6], and these two substances showed identical reactions with the spray reagents mentioned above. *A* after re-crystallization from hot water and from ether–benzene had a melting point of 139° identical with that of dihydrocaffeic acid. Elementary analysis of *A* gave C, 59·51 per cent; H, 5·63 per cent; $C_9H_{10}O_4$ requires C, 59·33 per cent; H, 5·50 per cent.

B had a R_F value in the benzyl alcohol solvent of 0·93 while that of *A* was 0·82. This was in keeping with loss of the carboxyl group from *A* to give *B*. *B* was isolated and crystallized from petroleum ether as thin needles with m.p. 38–39°, which rapidly turned brown in air. Ethyl catechol has m.p. 39°[7,8] and rapidly turns brown in air. *B* and a synthetic specimen of ethyl catechol had identical R_F values in the two solvents mentioned above and a mixed melting-point showed no depression. *A* and *B* were therefore identified as dihydrocaffeic acid and ethyl catechol respectively.

It is possible that *p*-coumaryl quinic acid, also present in cider-apples[9], may be metabolized in a similar manner to chlorogenic acid for addition of *p*-coumaric acid to the same basal medium, and inoculation with the same strain of lactobacillus showed that this acid was metabolized.

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Loss of Immunizing Power of Staphylococcal Toxin during Routine Toxoiding with Formalin

IN order to render staphylococcal toxic supernatants safe for use as active immunizing agents, it is customary to incubate them with formalin, in concentrations of 0·3–0·8 per cent at temperatures between 37° and 40° C. for periods of up to two weeks[1,2].

In the work to be described, the effect of this process on the antigenicity of a protective factor in staphylococcal toxic supernatants was examined in mice.

The staphylococcal toxic supernatant used had been prepared from cultures of strain *CN*56, grown for three days on modified Dolman's medium in an atmosphere of oxygen containing 20 per cent carbon dioxide, and was stored at 2° C. with 0·02 per cent

Table 1

Immunizing agent	Dilution	No. of experiments	Serum alpha antihæmolysin titre before challenge	No. of survivors/ No. challenged
Toxin	1/50	2	2	20/32 (62%)
	1/100	2	0·12–1	8/23 (35%)
	1/200 or 1/250	2	0·25–0·5	4/30 (13%)
Toxoid	1/1	3	0·12–0·5	5/40 (12%)
	1/5 or 1/10	2	0·1	5/29 (17%)
	1/100	1	0·5	2/10 (20%)
Nil (Control)	—	3	< 0·1	7/43 (16%)

In the group immunized with 1/50 toxin, the protection was highly significant ($P < 0.001$); in the group immunized with 1/100 toxin, it was not significant ($P = 0.08$).

thiomersal as a preservative. It will be referred to as 'toxin'.

A portion of toxin was mixed with 0·35 per cent formalin, incubated at 37° C. for five days, and then stored at 2° C. ('toxoid').

White mice weighing 15–20 gm. were used as experimental animals. For toxicity tests and immunization, 0·5 ml. vol. of the preparations or their saline dilutions were injected subcutaneously over the back. Immunization consisted of two injections given one week apart. Ten to twelve days after the second immunizing injection, samples of blood were taken from the tails for the estimation of alpha antihæmolysin. The animals were then challenged by the intraperitoneal route, with 100 million staphylococci of a recently isolated coagulase-producing strain, grown overnight on agar slopes at 37° C. and suspended in 1 ml. saline in which 1 per cent human fibrinogen and 1 per cent fresh human plasma had been dissolved[3]. The animals were observed for seven days after challenge. Alpha hæmolysin and antihæmolysin titrations were performed according to the method of Burnet[4]; mouse sera were tested, without preliminary heat inactivation, against the international reference standard.

Toxoiding reduced the hæmolytic titre of the toxin from 1/300 to 1/3. The toxin killed 90–100 per cent of the mice in a dilution of 1/20, and 10–40 per cent in a dilution of 1/50. Loss of fur, severe scarring and occasional ulceration developed at the site of injection in mice surviving the administration of toxin diluted 1/50; moderate and mild reactions of similar nature followed injections of 1/100 and 1/200 dilutions, respectively. Injections of toxoid, undiluted or diluted, did not kill any of the animals or cause local reactions.

Results of representative immunization experiments are given in Table 1. Significant protection against death was evident in the group immunized with toxin diluted 1/50, and some protection probably in the group given toxin diluted 1/100, but none in the groups given toxoid in dilutions ranging from 1/1 to 1/100. The antigenicity of the protective factor was, therefore, grossly reduced during toxoiding.

Alpha antihæmolysin titres were variable. The response in mice receiving toxoid was somewhat lower than in mice immunized with toxin, but some antihæmolysin was produced even in the animals given the smallest amount (1/100 dilution) of toxoid. During the process of toxoiding, therefore, alpha hæmolysin appeared to maintain its antigenic potency better than the protective factor did, suggesting that the two antigens, and their corresponding antibodies, may not have been identical.

Batches of toxin and toxoid produced from other strains of staphylococci were also tested in mice for their ability to protect the animals against the effects of challenge by the same technique, and for their ability to produce alpha antihæmolysin. The results were in accordance with those described.

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Secretion of Progesterone by the Adrenal Gland

The importance of progesterone in adrenal function has been emphasized by a number of investigators. Beall and Reichstein[1] isolated a small amount from adrenal extracts, and more recently Hechter and others[2], using the perfused cow adrenal gland, showed that progesterone is an important intermediary metabolite for the synthesis of the adrenal corticoids. While the work reported here was in progress, Klopper *et al.*[3] demonstrated the presence of pregnanediol in the urine of ovariectomized women, but not in that of ovariectomized, adrenalectomized women. These, and other workers[4], have inferred that the pregnanediol in these cases is of adrenal origin. The following results support this conclusion inasmuch as they show that the adrenal gland can secrete progesterone.

Adrenal venous blood was collected from animals under pentobarbitone sodium anæsthesia. The blood was cooled over ice during collection, and the plasma separated by centrifugation. This plasma was then treated with sodium hydroxide[5] to give a final concentration of 0·5 per cent w/v. It was extracted twice with an equal volume of ether, and after evaporation of the ether extract to dryness, the residue was dissolved in 70 per cent methanol and passed through a nine-tube counter-current distribution system of methanol and light petroleum. This system was so arranged that progesterone had a partition coefficient of 1. The contents of the five central tubes were combined and concentrated, and this material was then chromatographed on paper. The spots were detected by ultra-violet contact photography, and those with the same R_F value as progesterone were eluted from the paper and estimated by ultra-violet spectrophotometry. The results, corrected for losses in the extraction procedure, are presented in Table 1.

Although progesterone has been detected in all cases, the number of observations made within the groups is too small to warrant a correlation of the progesterone-level with either the sex or the reproductive state of the animal.

The chemical identity of the progesterone extracted from the adrenal venous blood was based on: (1) the partition coefficient in the counter-current distribu-

Table 1

Species	Age, sex and reproductive history	No. of animals	Mean progesterone concentration μgm./100 ml. plasma (range in brackets)
Cattle	69-day old male	1	46·5
	334-day old male	1	10·4
	210-days pregnant female	1	46·8
	240-days pregnant female	1	30·8
Sheep	Non-pregnant female	4	9·8 (9·2–10·9)
	Ovariectomized non-pregnant female	3	23·5 (17·2–33·2)
	Pregnant female	4	16·0 (10·9–24·1)
	Ovariectomized pregnant female	1	9·4
	Adult male	4	13·0 (4·5–26·6)
	Castrated adult male	3	7·5 (3·4–13·4)
Pig	179-day old male	1	40·6

tion system; (2) the R_F value on the paper chromatogram; (3) the ultra-violet absorption spectrum of the chromatogram eluate. The pooled chromatogram eluates obtained from the two pregnant cows also gave an infra-red spectrum identical with that of progesterone.

While the level of progesterone in the adrenal venous blood is 10–50 times less than the corresponding corticoid level, it is 10–100 times greater than the concentration of progesterone in arterial blood collected at the same time. These results therefore show that the adrenal gland secretes progesterone.

We wish to thank Dr. R. K. Callow for carrying out the infra-red analysis, and Mr. L. E. A. Rowson for performing some of the operations.

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Control of Humoral Factors of the Zona Glomerulosa of the Adrenal Cortex

Selye has reported[1] that intraperitoneal injection of hypertonic saline resulted in characteristic changes in the zona glomerulosa of rat's adrenal gland. Broadening of the zona, blurring of cell outlines, foamy cytoplasm and swollen nuclei were seen in histological specimens. The fact that the zona glomerulosa can be stimulated by the sudden flooding of the organism with sodium chloride is rather striking in view of the statement that low sodium diet causes hypertrophy of this zone[2–4]. The effect is characteristic of sodium chloride, since other hypertonic solutions do not have the same action[1]. Kovács *et al.* have shown that the effect can be prevented by pretreatment with chloropromazine or by hypophysectomy[5,6].

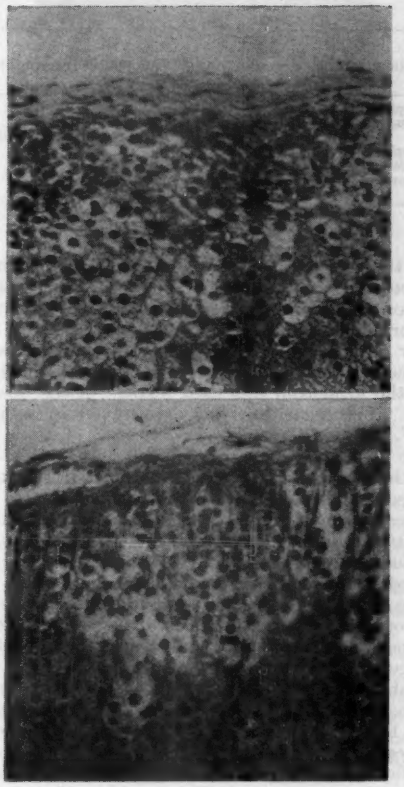

Fig. 1. *a*, Adrenal cortex of hypophysectomized rat treated with hypertonic saline. *b*, Adrenal cortex of rat with transplanted hypophysis treated with hypertonic saline. Note increased width of zona glomerulosa

Since these changes occur only in the presence of the pituitary, it may be assumed that one of the hormones of the anterior lobe, either a special corticotrophine[1] or another substance, might be responsible. Normal adrenocorticotrophic hormone is rather unlikely, because similar amounts of hypertonic glucose or urea representing nearly a fatal dose fail to bring about the changes. Presumably, the release of the effective substance from the pituitary is due to a specific stimulating action of hypertonic sodium chloride. The stimulating action of this stressor may ensue either through neural (intense pain) or humoral routes. Our experiments were designed in order to clarify this question.

Sixteen hypophysectomized male rats were given 4 ml. of a 10 per cent sodium chloride solution intraperitoneally, 15 days after the operation. The animals were divided into two groups. One group served as control. To the rats of the other group freshly removed rat's pituitaries (three per rat) were implanted subdermally 24 hr. before the injection of hypertonic sodium chloride solution. One hour after the injection the animals were killed and their adrenals were removed for histological study. The specimens were fixed in 4 per cent formalin for subsequent staining with hæmatoxylin–eosin. Quantitative evaluation of the results was made by karyometric examinations. Within the zona glomerulosa two diameters of 100 unselected nuclei were measured

Table 1

Group	No. of nuclei measured in the zona glomerulosa	Mean of log volume of nuclei	Probability
Hypophysectomized	800	2·0748 ± 0·1819*	$0·001 < P < 0·01$
Hypophysectomized + transplanted	800	2·7017 ± 0·1318*	

* Standard error of the mean.

with the aid of an ocular micrometer. From the diameters the volume of the nucleus representing a rotation ellipsoid could be calculated by means of the formula $4ab\pi/3$, where a means the shorter, b the longer diameter of the ellipse. Since the values so obtained do not correspond to the normal distribution, the logarithm was used instead of the absolute value. The logarithm was determined by a nomogram[7].

The results are given in Table 1. It may be seen that the nuclei of the zona glomerulosa in the 'transplanted' rats are larger than in the controls. The difference proved significant on statistical evaluation. Qualitative histological examination showed, too, that the changes reported by Selye were present in animals treated with pituitary grafts (Fig. 1).

The cells of the zona glomerulosa produce the hormone affecting the electrolyte balance (aldosterone)[8]. In present experiments the adrenal changes observed in the 'transplanted' rats fully resemble the histological changes corresponding to increased aldosterone secretion[9]. Our observations point to the importance of the pituitary in the genesis of these changes occurring after administration of a specific stressor by the humoral route. Further, our observations agree with the view that the pituitary participates in the regulation of aldosterone production. Further observations are being made to discover which of the pituitary substances cause the adrenal alterations described above.

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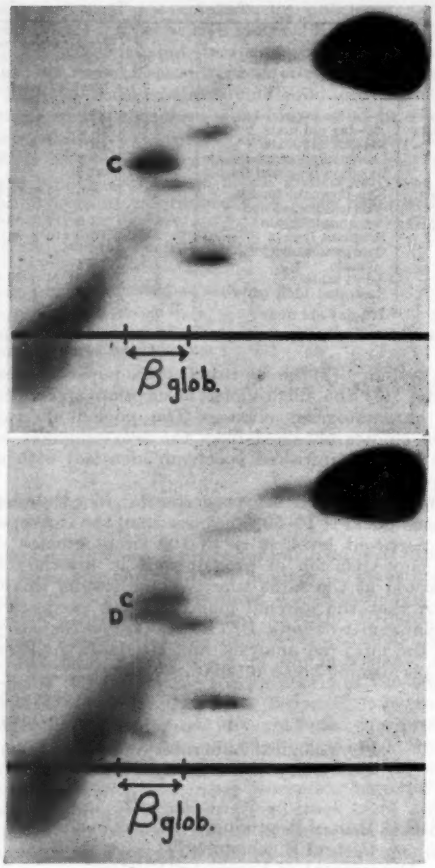

Fig. 1. Photographs of the results of two-dimensional electrophoresis experiments with (upper photograph) serum from a young White female, and (lower photograph) serum from a young Negro female. An additional β-globulin (*D*) is present in the serum from this Negro

Variations in Human Serum β-Globulins

Genetically controlled variations in the haptoglobins (α_2-globulins) of human serum have been demonstrated by electrophoresis in starch gels[1-3]. The frequencies of the genes controlling these proteins probably differ from one racial group to another[4]. Inherited differences in the serum proteins of dairy cattle have also been established using the same method, but in cattle the variable proteins prove to be β-globulins[5]. The frequencies of the genes involved differ in different breeds. This communication reports variations in human serum β-globulins which have now been found.

The β-globulin differences were noticed when sera were being investigated by the one-dimensional starch-gel electrophoretic method[1] chiefly used for the previous studies of human and cattle serum proteins. However, they can be established only with certainty when the two-dimensional electrophoretic method[6] is used. Fig. 1 illustrates the differences which can be observed. The upper part of the figure shows a photograph of the result of a two-dimensional electrophoretic experiment with serum from a young white female from Toronto. Four β-globulins (*A*, *B*, *C* and *E*) can be demonstrated in this serum. β-globulin *C* (labelled in the figure) is quantitatively much the most predominant. The lower part of the figure shows a photograph of the result obtained with serum from a young Negro female from New York. An additional β-globulin (*D*) is present in this serum, which migrates a little less rapidly than β-globulin *C* both on filter paper and in starch gel. When both β-globulin *C* and β-globulin *D* are demonstrable in a serum sample they appear to be present in approxi-

mately equal amounts in our limited experience to date.

The presence of β-globulin *D* has been established with certainty in serum from two female Negroes from New York (out of 22 males and 27 females tested), and in serum from four male and one female Australian aborigines (out of 17 males and 6 females tested). β-Globulin *D* has not been demonstrated in the serum from any of several hundred Canadians (largely of European ancestry) which have been studied, chiefly by one-dimensional starch-gel electrophoresis. These results suggest the existence of considerable racial differences in the frequency of occurrence in the serum of β-globulin *D*, and indicate that its presence may well prove to be genetically controlled.

I am grateful to Drs. Ralph E. Engle, jun., and James H. Pert of the New York Hospital, New York and to Dr. William R. Horsfall of the Commonwealth Health Laboratory, Cairns, Australia, for their kindness in sending me serum for study.

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Serological Studies on *Fusarium oxysporum* Schl. emend Sn. et H.

Morphological recognition of species of fungi which cause plant diseases present few problems, and it is usually not necessary to use serology in diagnosis. However, within a morphological unit physiological differences exist, and it might be possible to apply sero-diagnostic methods in distinguishing physiological races.

We have studied this problem on various physiological races of *Fusarium oxysporum* Schl. emend Sn. et H., which cause vascular browning and wilting of different host plants. Generally, cross-infection is not possible; for example, isolates of the fungus from *Pisum sativum* do not attack *Lupinus luteus* nor do those from *Lupinus luteus* attack *Pisum sativum*.

Single spore cultures of the isolates were grown on synthetic liquid media (Richard's and Czapek's solutions). Antisera were prepared by intravenous injection into rabbits of suspensions of microconidia, culture liquids and extracts of mycelia. Some rabbits produced specific antibodies which could be demonstrated best in gel diffusion precipitin tests[1,2]. Culture liquids seemed to be the most suitable test antigens in the precipitin tests.

The five tests illustrated in Fig. 1 were carried out simultaneously in one Petri dish; agar was poured into five small glass rings (27 mm. diam.) which had been glued with 'Araldite' to the bottom of the Petri dish. Several holes (4 mm. diam.) were punched into each agar plate. These reagent reservoirs were filled with antisera against *Fusarium oxysporum* f. *lupini* (Linf.) Sn. et H. and *Fusarium oxysporum* f. *pisi* (Linf.) Sn. et H. (further on designated as *L* and *P* respectively) and with the test antigens from these two isolates (*l* and *p*). The plate in the centre of Fig. 1

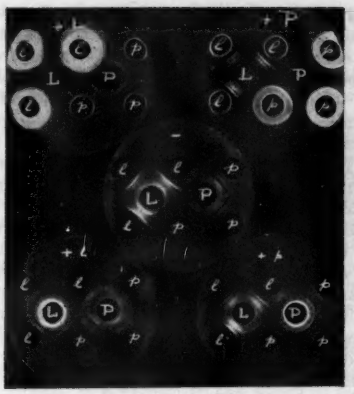

Fig. 1. Comparison of the culture liquids of *Fusarium oxysporum* f. *lupini* (*l*) and *Fusarium oxysporum* f. *pisi* (*p*) in gel diffusion precipitin tests. In the two plates above the agar is mixed with the antisera *L* and *P*, respectively; in the plates below with the antigen *l* and *p*

shows the specific precipitation pattern between *L* and *l* and between *P* and *p*. Frequently, there also appear lines, which represent antigens common to *l* and *p*.

When the agar has been mixed with *L* before pouring (Fig. 1, $+L$), the antigens diffusing from the reservoirs containing *l* are precipitated in a halo around the hole and no specific line between *L* and *l* is formed (specific inhibition of precipitation[3]). The specific reaction between *P* and *p*, however, is not inhibited by the presence of *L* and still results in a precipitation line. The reciprocal pattern is formed if the agar is mixed with *P* (Fig. 1, $+p$). Analogous results can be obtained by introduction of the antigens into the agar (Fig. 1, $+l$ and $+p$).

Further investigations are in progress, and full details will be published later.

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Effect of Acetylcholine and Quinidine on Atrial Cellular Potentials

Briscoe and Burn[1] have shown that acetylcholine will restore the spontaneous contractions of rabbit atria which have been arrested by quinidine. Armitage[2] has suggested that quinidine impairs repolarization by rendering the cell membrane less permeable to potassium ions, and acetylcholine restarts the tissue by restoring the potassium permeability. However, Weidmann[3], Johnson[4] and Johnson and McKinnon[5] have demonstrated that in cardiac muscle quinidine predominantly affected the depolarization phase of the action potential. The maximum rate of rise of the action potential was grossly decreased with little or no concomitant change in the membrane resting potential, indicating that the drug had a direct effect on the sodium-carrying system.

The obvious possibility exists that the restarting action of acetylcholine is due to an effect on the sodium-carrying system. Using the intracellular microelectrode technique (experimental details previously described[4]), we examined the effects of acetylcholine on isolated rabbit atria exposed to quinidine. The effects of quinidine sulphate ($2{\cdot}5 \times 10^{-6}$ w/v) were similar to those described for the guinea pig ventricle[4]. After 10-min. exposure to the drug the tissue lost its spontaneous rhythmicity and became electrically inexcitable; when acetylcholine chloride 10^{-6} was added the electrical excitability was restored, as evidenced by the transient appearance of action potentials. No accompanying change in membrane resting potential was detected. With repeated doses (10^{-6}) of acetylcholine the tissue regained its spontaneous rhythmicity.

We have also examined the effects of quinidine sulphate and acetylcholine on the sodium-carrying system by observing their actions on the maximum rate of depolarization of the action potential, which is an index of the sodium current[5,6]. Changes in the rate of recovery of the sodium-carrying mechanism were revealed by alterations in the maximum rate of depolarization of an isolated action potential evoked by an extra shock interposed between the sixteenth and seventeenth driving stimulus (rate 150/min.).

When treated with quinidine sulphate, $2{\cdot}5 \times 10^{-6}$, it was possible to evoke an extra action potential of markedly diminished rate of rise at a time when the repolarization of the previous action potential was completed, which incidentally indicated a dissociation between repolarization and the restoration of the sodium-carrying system. Acetylcholine chloride 10^{-6} increased the maximum rate of rise of both the normal and the extra action potentials, the latter being affected to a greater extent since the two values were often identical. As the extra action potential was evoked some time after repolarization of the previous action potential and acetylcholine had no effect on the membrane resting potential it seems that the increase in the maximum rate of rise of the extra action potential, caused by acetylcholine, could only have been due to a direct effect on the sodium-carrying system. We suggest the following hypothesis to explain the stimulant and inhibitory actions of acetylcholine described by Burn[7].

The usual inhibitory action of acetylcholine on the rate of beat of pacemaker cells could be explained by its action of increasing potassium permeability[8,9], thus diminishing the rate of diastolic depolarization responsible for rhythmicity. The arrest of atria by cooling, fatigue and quinidine-like agents is apparently the result of inactivation of the sodium-carrier mechanism. In the first two cases the inactivation of the carrier is probably the outcome of a reduced membrane resting potential[3,6,10]. In these cases the major effect of acetylcholine could be the increasing of potassium permeability, thereby aiding the restoration of the membrane resting potential and thus the activity of the carrier, yet a more direct effect of acetylcholine on the carrier cannot be excluded. However, in the case of quinidine the latter is the more important effect, for the carrier is inactivated with little or no change in the resting potential.

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Chemical Examination of the Water of Flooded Rice Fields

The marked root destruction that affects the crop of rice fields of limeless meadow clay and limeless alkaline soil is well known. The damage can be attributed mainly to the toxic effect of hydrogen sulphide and other products of anaerobic fermentation processes[1] (for example, butyric acid). Protein decomposition and sulphate reduction produce hydrogen sulphide[2]. The root-rot is much increased in horizontal roots produced chiefly by nitrogen excess, anaerobic conditions or soil defects. The roots just beneath the soil are fully exposed to the toxic products of the soil-biological processes below the surface.

To replace the destroyed roots, adventitious roots develop from the nodes. However, these solve only partly the problem of nutrient uptake by ion-exchange, since they remain in the water, which is poor in nutrients and lacks various essential elements.

To discover which nutrient ions may be present in the water at the time of the appearance of the browning disease ('bruzone'), fifty samples of water from each of both healthy (*H*) and unhealthy (*UH*) fields, as well as from fresh (*FW*) flood-water (River Tisza) have been subjected to analysis. Results are shown in Table 1.

As can be seen from these results, there is little difference in nutrient concentration between the water of healthy and unhealthy rice fields, therefore the cause of the disease must be ascribed to the fact that the diseased plants, which are dependent on their adventitious roots, can utilize only the nutrients dissolved in the water, in contrast to the healthy ones with their deep soil roots.

Table 1. Concentrations of Nutrients (mgm./l.) in Water Samples

Water sample	*p*H	Ca^{2+}	Mg^{2+}	K^+	Mn	Fe	NO_3^-	NH_4^+	SO_4^{2-}	PO_4^{3-}	SiO_2
H	7·4–8·1	25·7–48·2	18·2–24·3	4·8–8·1	—	0·0–0·1	—	0·0–0·3	—	traces	0·0–6·6
UH	7·1–7·3	43·1–52·8	8·6–19·3	4·7–11·2	—	0·0–0·05	—	0·0–0·1	—	—	2·6–5·6
FW	7·2	34·2	7·01	3·9	—	0·05	—	—	50·1	—	6·0

Table 2. NUTRIENTS AND S^{2-} (MGM./100 GM.) IN SOIL SAMPLES

Soil sample	NO_3–N	NH_3–N	P_2O_5	K_2O	Total-N	S^{2-}
1	—	2·6	2·8	6·3	125	8·0
2	—	4·5	7·2	4·0	161	4·6
3	—	2·8	12·7	5·8	219	7·4
4	—	9·6	9·0	10·8	213	5·24

The quantity of the available nutrients in the soil of the affected fields at the time of the appearance of the disease is given in Table 2.

The water of the diseased fields was as a rule deficient in phosphate, sulphate, nitrate and manganese. Moreover, ammonium and iron were absent or present only in minute quantities. In the water of healthy fields there was a trace of phosphate and slightly more, but still very little, ammonium. Owing to the absence of the elements mentioned above, the adventitious roots cannot replace the activity of the soil-roots, so that the life-processes of the plant may be checked. The dark or bluish green colour of the plant denotes the absence of phosphorus, involving the cessation of protein synthesis. Biochemical examination shows in every case a higher ammonia–nitrogen content than amide–nitrogen in the affected plants[3].

It is root-rot, the deficiency diseases mentioned above, metabolic disturbances and fungi on affected plants (*Helminthosporium oryzae*, *Piricularia oryzae*, *P. grisea*, etc.) that cause the symptoms known as blast, brown disease, 'bruzone', 'aki-ochi', Brand, etc.

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Molybdenum Deficiency in Latosols of Java

RECENT experiments with groundnuts, *Arachis hypogea*, on the Muara plots near Bogor, Java, have shown that small applications of molybdenum produce a markedly beneficial effect on the colour and growth of this legume when grown on latosols of this area. The beneficial effect was not confined to one soil mapping unit in the plot field, and since latosols are widely distributed and extensive, especially in the moist tropics, the desirability of a thorough investigation of trace-element deficiency in these leached soils is indicated.

Arnon (1937) demonstrated in pot culture experiments that molybdenum is essential for barley, and Arnon and Stout[1] showed that it is essential for tomatoes. Molybdenum deficiency in the field was first recognized, in Australia, by Anderson[2], with clovers on acid sandy soil. Legume root nodule bacteria are apparently unable to fix nitrogen in the absence of an adequate supply of this element, and investigations of other nitrogen-fixing micro-organisms have shown that they also require molybdenum for this purpose. Mulder[3] and Hewitt and Jones[4] have shown that molybdenum-deficient plants do not reduce nitrate efficiently after it is absorbed and transferred to the upper parts of plants. This may account for the beneficial effect of molybdenum to non-legumes.

An experiment with groundnuts was started on the Muara plots near Bogor, Java, in January 1957, to study the effects of trace elements and other elements not commonly used as fertilizers, in addition to the fertilizers commonly used on legumes, namely, phosphorus, potassium and lime. The soil is a latosol derived from volcanic ash and its *p*H value is about 5·5. Latosols are characteristically acid, leached, reddish soils, and soils of this kind are very common in Indonesia and other moist tropical areas. It is reasonable to expect that such soils will be deficient in fertilizing elements that are normally present in adequate quantities in less severely leached soils.

The experiment was designed to test the effects of phosphorus, potassium and lime, applied singly and in combinations, in addition to the effect of elements not commonly used as fertilizers. A mixture of manganese, magnesium, copper, boron, zinc and molybdenum compounds was applied to plots treated with a combination of phosphorus, potassium (as sulphate) and lime. The treatments were randomized in four blocks, thus giving four replicates of each. The beneficial effect of the mixture was shown by the definitely greener colour of the foliage, which became evident about one month after planting, and by the increased growth which followed. These effects have been recorded in colour photographs and by yield data. It should be noted also that the greener growth was accompanied by much better nodulation, as revealed by examination of the plant roots.

A second field plot experiment with groundnuts was started in the Muara field late in May 1957, with the object of determining the factor responsible for the beneficial effect. As the number of plots available for this experiment was rather limited, one element, manganese, was excluded because it seemed unlikely that it would be deficient in this soil. The treatments were as follows: (1) check, (2) a mixture of magnesium, copper, boron, zinc and molybdenum compounds, (3) double superphosphate, potassium sulphate and lime. The other treatments consisted of combinations of one or more of the five elements under investigation (listed under (2)) with the phosphate, potash and lime. The system was to use all five elements, then remove one at a time, then two, etc. The treatments were randomized in four blocks as before, thus giving four replicates of each. The weather was dry for about 3 weeks after planting, and the differences did not become evident for about 6 weeks. After 8 weeks it was observed that all 32 plots that did not receive molybdenum were somewhat yellow or less green than the adjacent plots that received this element. There are 88 plots altogether. The treatments included one with molybdenum only and one with magnesium, copper, boron and zinc (in addition to the basic phosphate, potash and lime), and the former plot was much greener than the latter. It is thus evident that the soil is deficient in molybdenum for groundnuts, and since nodulation was obviously improved by the application of molybdenum, it is reasonable to expect that other legumes would benefit likewise. Without molybdenum the crop appeared to be suffering from lack of nitrogen. Yield data will be published later.

The molybdenum was applied at the rate of 1 kgm. per hectare of sodium molybdate, or about 1 pound

per acre. Of all the elements known to be necessary for plants, molybdenum appears to be required in the smallest quantities.

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A New Hæmoglobin Variant exhibiting Anomalous Electrophoretic Behaviour

In moving-boundary electrophoresis, cacodylate buffer, *p*H 6·5, μ0·1, the relative mobilities of the better-known hæmoglobin variants are the same or only slightly different from those in paper electrophoresis, veronal buffer, *p*H 8·6, μ0·05. Owing to the fact that the two buffers are on the opposite sides of the isoelectric points of these types of hæmoglobin, the order of migration is reversed; however, the relative mobilities of hæmoglobin types *A*, *S*=*D* and *C* are identical under both conditions. The earliest instance of a type of hæmoglobin exhibiting some discrepancy in behaviour in free electrophoresis as compared to paper electrophoresis is that of hæmoglobin *F*; with the latter technique, the mobility of *F* is always slightly less than that of *A*, but with the former, *F* is indistinguishable from *A*. A somewhat greater difference occurs in the mobility of hæmoglobin *E*, which, in veronal paper electrophoresis (*p*H 8·6), lies between *S* and *C*, but in free electrophoresis (cacodylate, *p*H 6·5) is slightly less than that of *S* (between *S* and *A*)[1]. Similarly, the mobility of hæmoglobin *G* lies between *F* and *S* in paper electrophoresis at *p*H 8·6; but in free electrophoresis at *p*H 6·5 (cacodylate) *G* is inseparable from *S*[2].

The present communication deals with a hitherto undescribed type of hæmoglobin, the resolution of which is completely different in moving-boundary electrophoresis at *p*H 6·5 (cacodylate buffer) from that in paper electrophoresis at *p*H 8·6 (veronal buffer).

This hæmoglobin sample was obtained from 'MTu', a Negro obstetric patient whose clinical and hæmatological history is not contributory. 'MTu's' hæmoglobin, examined by paper electrophoresis (veronal buffer, *p*H 8·6, μ0·05[3]), separated into two approximately equal components, of which one appeared identical with hæmoglobin *A*. The other assumed a position overlapping that of hæmoglobin *G*, and extending almost to that of hæmoglobin *S*, resembling hæmoglobin *L*; however, in moving-boundary electrophoresis, cacodylate buffer, *p*H 6·2–6·9, μ0·1, unlike a hæmoglobin *AL* mixture, 'MTu's' hæmoglobin moved as a single sharp peak (Fig. 1).

Table 1. Free Electrophoresis of Mixtures of 'MTu's' Hæmoglobin with Other Types

'MTu's' hæmoglobin mixed with a sample of hæmoglobin from		Proportions of mixture	Quantitative evaluation of patterns
Name	Type of hæmoglobin		
'JW'	*A*	1 : 1	One sharp peak
'SS'	*S* (3% *F**)	1 : 1	Two peaks with 63 per cent in leading one
'DW'	*S* (6% *F**)	1 : 1	Two peaks with 54 per cent in leading one
'BA'	*S* (2% *F**)	2 'TMu' : 1 'BA'	Two peaks with 74 per cent in leading one
'AK'	*AG* (50% *A*†)	1 : 1	Three poorly separated peaks with about 50 per cent in leading one and 25 per cent in each of the other two
'ET'	*AG* (35% *A*†)	1 : 1	Two peaks with about 90 per cent in leading one
'ET'	*AG* (35% *A*†)	2 'ET' : 'MTu'	Two peaks, approximately equal

Cacodylate buffer, *p*H 6·5, μ0·1
* Value obtained by method of alkali denaturation.
† Value calculated from previous scanning diagrams.

Aliquots of 'MTu's' hæmoglobin were added to those containing various known types of hæmoglobin and the mixtures were analysed in free electrophoresis, cacodylate buffer, *p*H 6·5, μ0·1. The results are given in Table 1. Mixtures of hæmoglobin *A* and 'MTu's' sample again moved as one sharp peak. Mixtures of 'MTu's' hæmoglobin with hæmoglobin *S* from subjects with sickle-cell anæmia resolved into two peaks of variable proportions. Similarly, mixtures of 'MTu's' hæmoglobin sample and those containing hæmoglobin of types *A* and *G*, from patients 'AK'[4] or 'ET' (Schneider, R. G., unpublished data), resolved into two peaks of inconstant proportions, and on two occasions into three partially separated peaks. 'MTu's' hæmoglobin sample was also analysed in free electrophoresis, using veronal buffer, *p*H 8·6, μ0·1, in which buffer there resolved one peak and a shoulder of another.

The hæmoglobin of 'MTu's' husband was entirely of type *A*. Of her two children, one had only type *A*; the hæmoglobin of the other child ('HBTu') was first obtained at the age of seven weeks. In paper electro-

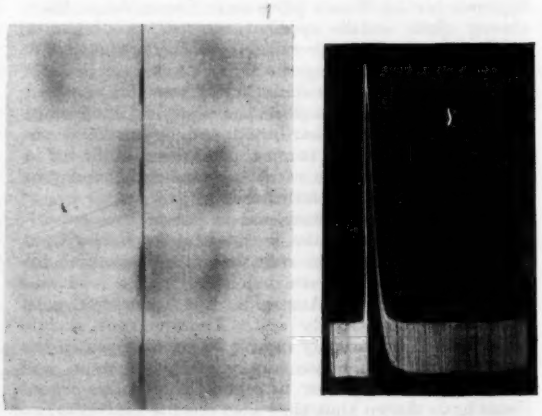

Fig. 1. Paper electrophoresis pattern and scanning diagram of hæmoglobin of 'MTu'. Paper electrophoresis veronal buffer, *p*H 8·6 μ0·5 (paper impregnated with 0·5 per cent egg albumin before analysis). Scanning diagram, ascending pattern 1 per cent carboxyhæmoglobin, cacodylate buffer, *p*H 6·5, μ0·1
* Sample from patient 'AK'

phoresis this sample consisted primarily of type *F*, with smaller amounts of type *A* and of another type similar to the variant in the mother. The *F* hæmoglobin value, by the method of alkali denaturation, was 38 per cent. In free electrophoresis, cacodylate buffer, *p*H 6·5, there was one peak only. This child was examined again at the age of four months, at which time his hæmoglobin pattern in paper electrophoresis was almost identical with that of the mother.

When 'MTu's' hæmoglobin was analysed in paper electrophoresis in a closed system (between glass plates) its pattern was indistinguishable from that of hæmoglobin *AS*. This was also the case in some analyses of less than eighteen hours duration in the present method of paper electrophoresis. This finding suggests the need for caution in interpreting the results of analyses by paper electrophoresis, particularly with respect to identification of hæmoglobin *D*, *L* and *G*, the variants most likely to be confused with the one present in 'MTu'.

It is suggested that the hæmoglobin variant in 'MTu' and her son 'HBTu' be tentatively designated the 'Galveston type'.

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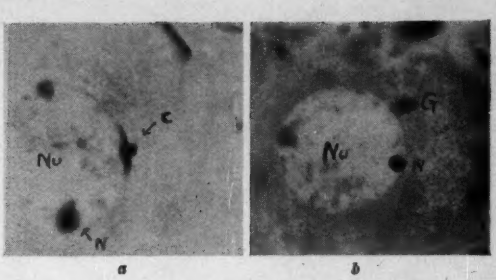
Mitochondrial Kinetics

VISIBLE local modification of the cellular nuclear membrane is usually considered a phenomenon associated with the discharge of nucleic acid from nucleus to cytoplasm. Barr and Bertram[1] have noted thin 'nuclear caps' in nerve cells concomitant with the reproduction of Nissl substance during recovery from antidromic stimulation. Such 'nuclear caps' appear as distinctive dense or thickened local areas of the nuclear membrane which stain with basic dyes, give positive histochemical reactions for nucleic acid, and absorb heavily at 2600 A. with ultra-violet light methods. Electron studies also indicate that the membrane may be thickened and modified during regeneration after axonic severance[2].

However, modification of the nuclear membrane interface may occur during intracellular processes seemingly unconnected with nucleic acid interchange. Earlier studies[3] have shown that cytoplasmic organellæ, the lipochondria, may enter into relationship with the nucleus, forming a zone of nuclear reaction morphologically indistinguishable from a 'nuclear cap'.

Striking examples of these 'caps' have recently been found in dorsal root ganglion cells of neonatal guinea pigs. The photomicrographs (Fig. 1) are from preparations fixed in Helly fluid, and post-chromed before staining with Altmann's mitochondrial stain. At one pole of the nucleus the membrane is thickened and contains some distinct granules (Fig. 1,*a*). The whole structure is strongly fuchsinophil and is



a *b*

Fig. 1. *a*, Dorsal root ganglion cell, neonatal guinea pig. A nuclear cap *C* contains two granules. *N*, nucleoli; *Nu*, nucleus. (× *c.* 19,000). *b*, A mass of fuchsinophil granules *G* lie close to the nuclear membrane. Less strongly stained mitochondria are present in the section but are not clearly visible in this plate. *N*, nucleoli. (× *c.* 19,000)

sharply differentiated from the rest of the nuclear membrane.

Frequently, masses of similar fuchsinophil granules lie in contact with, but outside of, the nucleus, and may or may not be associated with a 'nuclear cap'. These masses stain as do the mitochondria, but with greater intensity. Granules at the periphery of the mass merge with and become indistinguishable from the normal mitochondria (Fig. 1*b*). Both the 'nuclear caps' and their associated granules give a negative Feulgen reaction, and do not stain with pyronin in Brachet's method for ribonucleic acid.

Although nucleoli frequently approach and attach themselves to the nuclear membrane from the inner aspect they are not then similarly associated with the formation of a distinctive fuchsinophil cap (Fig. 1*b*).

The above phenomena suggest a possible mitochondrial kinesis involving the nucleus, similar to that already described for the lipochondria. A slide illustrating these phenomena will be sent to the International Depository of Cytological Slides, Institute Carnoy, Louvain, Belgium.

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A Cell Compressor for the Measurement of Mass and Concentration by Interference Microscopy

FOR a number of observations with the interference microscope on suspensions of living cells, it is desirable to be able to make the upper and lower surfaces of the cell flat and parallel without producing irreversible damage. A number of compressors are known (for example, Rousselet), but none provides quite the degree of control which is required. The compressor illustrated in Fig. 1 depends upon the bending of the slide S_2 and is therefore completely free from shear play and other uncontrollable movements, unlike compressors which depend upon sliding motion. In addition, the mounting of the cells on the small strip of glass *B*, which is sealed to the lower slide S_2 with 'Araldite', avoids any disturbances due to changes in capillary attraction. The curvature of the meniscus at *M* is little affected by small changes in the gap *G*. These two conditions enable quite reversible changes in the gap to be effected over distances

Table 1. Response of Normal Liver and Hepatoma Cells to Polyethylene-imine

Measurements of cytoplasmic concentration calculated from specific protein increment (ref. 2) and expressed as gm./100 c.c. water. Measured before and after introducing 0·12 per cent polyethylene imine in calcium-free Locke's solution

Experiment 1*
Normal liver cells compressed to thickness of $8·5 \times 10^{-4}$ cm.

	Cell No. 1	2	3
Time		Concentration	
Zero, reagent introduced	10·8	11·7	11·7
7 min.	11·7	12·3	13·3
17 ,,	12·5	13·3	13·8
30 ,,	13·2	12·8	14·3

Experiment 2
Hepatoma cells compressed to thickness of $7·6 \times 10^{-4}$ cm.

Time			
Zero, reagent introduced	16·7	16·3	17·2
10 min.	16·3	0	21·4
20 ,,	11·2	0	22·7
30 ,,	0	0	16·3

of about two microns. The actual thickness of the gap can be readily measured on the microscope with the help of an air bubble as previously described[1]. In addition, the medium surrounding the cells can be easily exchanged in this compressor without producing capillary disturbance.

The compressor can be used for direct observation with the interference microscope, for example, to immobilize ciliates such as *Paramecium* by light compression. It can also be used for measuring the refractive index and hence the concentration of material in various parts of the cell. It has been used, for example: (*a*) To study the effects of various positively charged polyelectrolytes upon normal and homologous tumour cells. An increase in permeability of the membrane is revealed by a fall in cytoplasmic concentration. In a typical preliminary experiment using polyethylene imine (Table 1) the concentration of cytoplasm in the tumour cells (hepatoma) fell quite rapidly, whereas the normal liver cells showed no decrease. (*b*) For measurements on *Amoeba proteus*. These indicate that the contractile vacuole has a concentration which is the same as that of the external medium (water); the concentration in the plasmagel at the rear contracting end of the cell was the same as that at other parts of the cell, including the anterior end. Contraction cannot therefore be due to loss of water, as suggested by Pantin (1923).

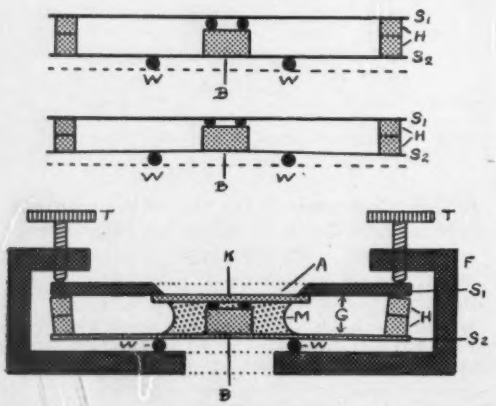

Fig. 1. Top: Arrangement of the two slides S_1 and S_2 with platform B carrying cells on upper surface.
Middle: Slide S_2 bent towards S_1 by wire bars W; downward forces applied at ends of S_1. Upward curvature of S_2 produces compression of cells.
Bottom: Longitudinal section through complete compressor showing screws T (remote from objective), either or both of which produce bending of S_2.
S_1, glass slide (for low power observation) or 'Dural' plate with central aperture A and coverslip K cemented to lower surface (for high power observation); S_2, glass slide with spacers (H) consisting of two thicknesses of glass coverslip cemented to upper surface. Glass platform (piece of cover-slip) (B) cemented to upper surface with 'Araldite' across centre of slide. W, wire bars 1 mm. thick; F, metal frame carrying thumbscrews T for controlling the thickness of the gap G, provided with central aperture for illumination with condenser

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Use of a Histochemical Technique to demonstrate the Cutaneous Penetration of Adrenalin and Nor-Adrenalin

Although histochemical techniques are commonly used for demonstrating substances in their normal situations in tissues they may also be used for demonstrating such substances in more unusual sites.

An example of this is the demonstration of the passage of adrenalin through the skin of a rabbit.

Fatty emulsions containing a 1 in 500 concentration of adrenalin in one preparation and nor-adrenalin in the other were rubbed on to the shaved skin of a rabbit and pieces of skin removed under ether anæsthesia at intervals of 5 min., 20 min. and 1 hr.

The skin upon removal was placed in 5 per cent ammoniacal solution of silver nitrate. It remained

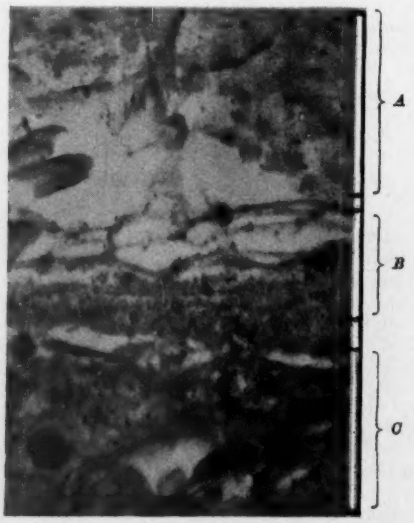

Fig. 1. Section through rabbit skin 5 min. after application of emulsion containing 1 in 500 adrenalin to the surface. Black silver granules indicating the penetration of adrenalin between the epithelial cells can be seen. Silver granules can also be seen in the emulsion above the epithelium and in the subcutaneous connective tissue

in this solution for one hour. It was then washed, and frozen sections cut from one half of each piece of skin—the other half being dehydrated, embedded in wax and sectioned in the usual way. Sections were afterwards toned in gold chloride to remove the overall brown stain. Granules of reduced silver were present wherever the adrenalin or nor-adrenalin had penetrated.

It was found that even by 5 min. there had been a complete penetration of the skin by both adrenalin and nor-adrenalin and that there was even evidence of their presence in the subcutaneous tissues. They appear to penetrate between the cells rather than through them. Although there are other reducing substances present in tissues which can reduce ammoniacal silver nitrate, treatment of pieces of control skin treated with the emulsion devoid of adrenalin showed only a few black granules.

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Paper Chromatography in Taxonomic Work

A method for using paper partition chromatography for taxonomic studies on land snails has been described by Kirk *et al.*[1].

In attempting to use the original technique, a number of technical difficulties were encountered, and it was found that exactly reproducible results were not easily obtained. The main source of error lay in the fact that Kirk and his co-workers ran their chromatograms on a glass plate covered by an inverted pie-dish, the solvent being fed to the centre of the disk by a wick passing through a hole in the glass plate. As a result, the chamber (the lumen of the covering dish) only becomes saturated with solvent vapour by evaporation from the surface of the disk during the run. It is also almost impossible to standardize the wick feeding the solvent.

These sources of error are eliminated by the use of the standard circular chromatography apparatus described by Kawerau[2]. By using slotted Whatman No. 3 papers 26 cm. in diameter, and a standard run of six hours at about 20° C., quite easily reproducible results are obtained. The R_F values of the fluorescent bands resulting from this technique are greater than those obtained by the original method, partly due to the elimination of surface evaporation from the paper and partly because of the differential flow-rate at the solvent front as it moves farther from the centre along the sectors of the paper. Thus the R_F values obtained from a four-hour run are a little lower than they are after six hours.

The method not only works well with some land snails but also with some aquatic groups, and interesting results are at present being obtained from the genus *Lymnaea*.

We are indebted to Mr. E. R. Shandon for the loan of the Kawerau dishes used and for the specially cut papers.

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Respiratory Characteristics of Marine Bacteria

Bacteria which are isolated from marine environments and require for growth a medium containing sea water are classified as true marine organisms. Recent evidence[1] indicates that the inability of marine bacteria to grow in the absence of sea water is due to a requirement for specific inorganic ions. A second, but not as well-defined, characteristic of marine bacteria is their high proteolytic activity and their rapid growth on organic nitrogen compounds[2].

The majority of studies of the metabolic activities of marine bacteria are concerned with requirements for growth. Seldom have the respiratory characteristics of a marine bacterium been investigated and correlated with growth studies. It was therefore of interest to determine if the criteria used for distinguishing marine bacteria as a group are satisfied by respiratory as well as growth characteristics.

The respiratory activity of a marine bacterium and *Escherichia coli* on endogenous and exogenous substrates, in the absence and presence of sea water, was determined using a Warburg respirometer and conventional manometric procedures[3]. The marine bacterium used in these studies was isolated from sea water collected in the vicinity of Fort Johnson. The growth requirements of the organism fulfil the criteria for its designation as a true marine bacterium. The culture is identified as *A*–11–3*B*1 in the Fort Johnson collection.

Table 1 shows that oxygen uptake by the marine bacterium on both endogenous and exogenous substrates was much greater in sea water than in phosphate buffer. With *E. coli*, conditions were reversed, that is, oxygen uptake on both endogenous and exogenous substrates was greater in phosphate buffer than in sea water. Tests showed that the reduced oxidation of glucose by *E. coli* in sea water was not the result of a deficiency of phosphate.

It is evident from Table 2 that the marine bacterium respires preferentially on some component(s) of casamino-acids. Casamino-acids were oxidized rapidly, whereas galactose and glucose were oxidized at a very low rate. It was not possible to replace casamino-acids with asparagine, glutamate, or glycine. Asparagine, citrate, and glycerol reduced endogenous respiration.

While investigation was in progress, Tomlinson and MacLeod[4] reported that the inorganic ion requirements for growth of a marine bacterium were also necessary for its oxidation of exogenous substrates. This provides further evidence that the growth requirements used for defining marine bacteria as a

Table 1. Oxygen Uptake by a Marine Bacterium and *E. coli* in Sea Water and Phosphate Buffer

Suspending medium	Substrate	μl. oxygen consumed in 1 hr. at 28° C.	
		Marine bacterium* (*A*-11-3*B*1)	*E. coli*† (Strain *B*)
Sea water‡	−	48·0	13·0
Buffer§	−	16·7	23·5
Sea water	+	212·4	124·0
Buffer	+	83·5	201·3

* 3×10^{10} cells of a 24-hr. culture were added per flask, and 0·17 per cent casamino acids added as substrate.
† $2·7 \times 10^{9}$ cells of a 24-hr. culture were added per flask and 0·03 *M* glucose added as substrate.
‡ Fresh sea water collected in the vicinity of Fort Johnson and passed through a millipore filter before use, *p*H 8·1.
§ *M*/15 phosphate buffer, *p*H 8·0.

Table 2. The Influence of Substrate on Oxygen Uptake by a Marine Bacterium

Substrate*	μl. oxygen consumed in 1 hr. at 28° C.†
Asparagine (0·03 *M*)	−10·1
Casamino-acids (0·17 per cent)	191·8
Citrate (0·03 *M*)	−2·6
Galactose (0·03 *M*)	23·3
Glucose (0·03 *M*)	21·3
Glutamate (0·008 *M*)	1·6
Glycerol (0·03 *M*)	−0·9
Glycine (0·03 *M*)	27·5
Malate (0·03 *M*)	5·5

* All substrates dissolved in filtered sea water collected in the vicinity of Fort Johnson. Where necessary the *p*H was adjusted to 7·5–8·0.

† Each flask contained 7 × 10⁸ cells of a 48-hr. culture, washed and suspended in filtered sea water.

group are reflected in their respiratory characteristics, and that true marine forms might be distinguished by manometric as well as by growth studies.

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Two Inhibitory Fibres forming Synapses with a Single Nerve Cell in the Lobster

In the stretch receptors of lobsters described by Alexandrowicz[1] the dendrites of sensory neurons lie in a fine muscle strand. Stretch-deformation by passive pull or by contraction of the receptor muscle leads to depolarization of the dendrites and of the adjacent cell body and axon region, thus setting up sensory discharges. In most lobster receptors Alexandrowicz also found two efferent neurons, a thick and thin 'accessory' fibre, forming synapses in the dendritic region of the sensory cells. Both accessory fibres divide and send one branch to the slowly adapting neuron and the other to the fast adapting receptor cell (Fig. 1). It has already been shown that stimulation of the thick accessory fibre can promptly suppress the sensory discharge caused by stretch of the muscle strand[2]. This axon therefore has a specific inhibitory role.

It has now been possible to stimulate both accessory fibres individually and determine their action on the discharge of a single slowly adapting receptor cell. As expected from the diameter difference the small axon has a slower conduction velocity and a higher threshold. If stimulated it has a specific inhibitory

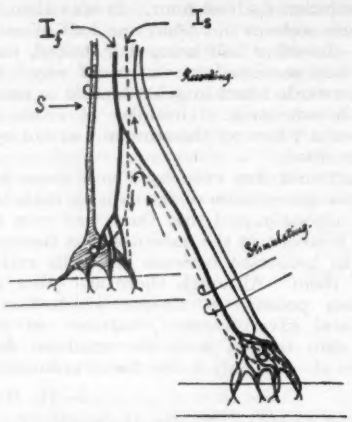

Fig. 1. Diagram of double inhibitory supply to sensory neurons in the lobster stretch receptor. *S*, slowly adapting sensory cell from which afferent impulses are recorded; I_f and I_s, fast and slowly conducting inhibitory axons forming synapses with dendrites of sensory cells. Inhibitory fibres are stimulated near the fast adapting receptor cell (no shading) and their impulses conduct centrally (arrows) to the recording electrodes, and, by axon reflex, to the slowly adapting neuron

action similar to that of the larger inhibitory fibre. Thus the same sensory neuron possesses a double inhibitory (*I*) supply. There are, however, definite differences in the inhibitory action if tests are made on an individual sensory neuron under identical experimental conditions. An example in Fig. 2 shows a sensory cell discharging at a steady rate near 6/sec. Stimulation of the thick or 'fast' *I* neuron at 15/sec. *A* reduces the discharge rate while 20/sec. completely inhibits it (*B*). To obtain a similar inhibitory action the thin or 'slow' *I* fibre had to be stimulated at a much higher rate, namely, 30/sec. (*C*) and 40/sec. (*D*). The difference in inhibitory effectiveness was always seen. The inhibitory effects of the 'slow' and 'fast' *I* axons can sum.

These results may be of interest because dual inhibitory regulation of one cell by two neurons with distinctly different physiological performance has not yet been found elsewhere. The differences in synaptic events and in membrane changes caused by the two inhibitor axons are being studied.

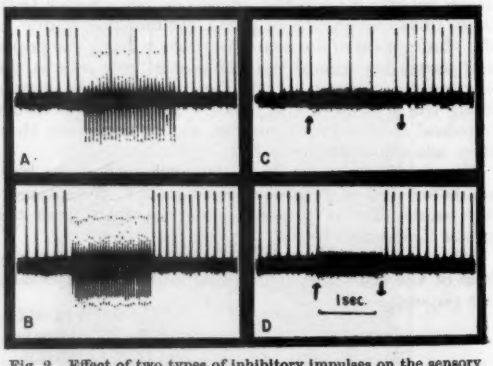

Fig. 2. Effect of two types of inhibitory impulses on the sensory discharge of a slowly adapting stretch receptor neuron. The afferent discharge-rate in all records is near 6/sec. Stimulation of the 'fast' inhibitory axon at 15/sec. *A* causes incomplete inhibition while at 20/sec. *B* all discharges are suppressed. A comparable inhibitory effect by the 'slow' inhibitory impulses requires stimuli at 30/sec. *C* and 40/sec. *D*. Period of inhibitor stimulation in *A* and *B* is marked by artefacts, in *C* and *D* by arrows

This work was done at the Marine Biological Laboratories, Woods Hole, Mass.

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A 'Window' Technique for Observing Fish Viscera *in vivo*

Descriptions of the behaviour of viscera seen *in vivo* are rare compared with the numerous observations made on preparations isolated from the body and maintained under conditions varying to a greater or lesser extent from their normal physiological environment. A 'window' technique has been developed which allows close observations to be made of the movements of the gut of fish which are living and feeding under normal conditions. It was originally designed for observing the normal gastric motility of the brown trout (*Salmo trutta*), but was later more fully developed for the pike (*Esox lucius*).

The fish was first anæsthetized by plunging into 2 per cent urethane for 45 sec. and then transferring it to a weaker solution (0·5 per cent). During the operation, the head and gills remained immersed in the anæsthetic. The bottles containing the anæsthetic solutions were placed in the fish tank prior to use, for temperature equilibration.

The body cavity was opened ventrally with a cut at right angles to the longitudinal axis of the body. An aperture about 2 in. long and 1 in. wide was made in the side of the fish, between the pectoral and pelvic fins. Relatively little hæmorrhage was produced by the incision.

The window was then fitted. This consisted of a sheet of mica (0·01 cm. thick). (For various reasons, neither celluloid, polythene, polyvinylchloride, nor thin rubber were successful transparent materials for making windows.) Two sharpened aluminium studs, tapped at both ends, were pushed through the corners of one end of the mica sheet and on through the dorsal musculature of the abdominal region of the fish. The mica was looped around the ventral surface of the fish, enclosing the cut abdominal section, and was pierced by the other ends of the studs emerging from the body wall. Four 'Perspex' nuts were then screwed on to the aluminium studs so that a firm, compact, transparent, window covered the hole in the side of the fish. The final arrangement can be seen diagrammatically in Fig. 1.

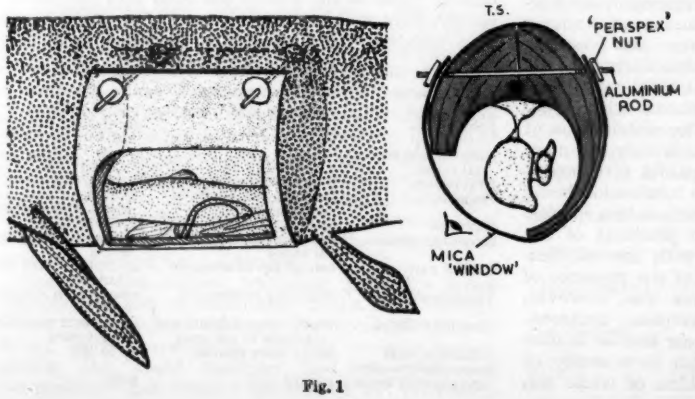

Fig. 1

The fish took about 2 hr. to recover from the anæsthetic and another 24–28 hr. before their behaviour appeared to be normal.

Pike equipped with windows have been kept for more than four months, during which time they were capable of feeding on small fish. On the other hand, trout fitted with the same or differently designed windows never survived for more than four days. There are probably a number of reasons for this striking difference in survival-time of the two fish under similar conditions. The main reason may be that the window used in these experiments did not form a perfect seal for the body cavity. The violent body undulations of the trout allowed seepage of tank water into the body cavity, whereas the long abdomen of the pike remained rigid most of the time, so that exposure of the viscera to tank water happened very rarely, if at all.

The pike has the further advantage for observation of its internal organs that it lies very still for long periods of time, so that a microscope can be focused on the viscera. In addition, there are no pyloric cæca or heavy deposits of fat in the pike body-cavity, both of which tend to obscure the view in the trout.

For fish more active than the pike, a special 'Perspex' observation bracket was made to reduce movements to a minimum (Fig. 2). It was designed to be placed in the fish tank, so that normal conditions of air, light, temperature and background should remain unaltered. The bracket was so shaped that a posterior, V-shaped piece restrained tail movement to a minimum. A perforated plunger was then pushed into the open end of the chamber until it almost touched the nose of the fish. In this way, the chamber could be adapted to accommodate fish varying from 8 to 16 in. in length. Fish appeared to behave normally in this bracket after a few hours. Part of the bracket was left open so that the fish could be fed.

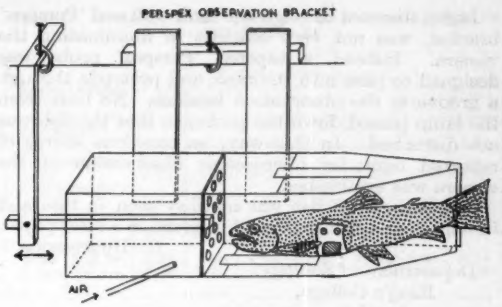

Fig. 2

Light, directed through the tank wall and 'Perspex' bracket, was not very efficient in illuminating the viscera. Instead, a tapered 'Perspex' probe was designed to pass into the tank and protrude through a groove in the observation bracket. No heat from the lamp passed down the probe, so that the fish was not disturbed. In this way, an excellent source of reflected light for microscopic observation of the viscera was established.

Comparisons of fish gut motility seen *in vivo* and *in vitro* in an organ bath will be given in a later paper.

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Mucous Gland Cells of the Outer Mantle Epithelium of *Arca noae*

Mucous gland cells occur in the outer mantle epithelium of most lamellibranchs, in some relatively commonly, for example, *Pinna*[1], in others less frequently, for example, *Mytilus*, *Ostrea*, *Tellina*. In *Arca noae*, cells with two different types of histochemical properties have been observed throughout the outer mantle epithelium but most commonly proximal to the line of attachment of the pallial muscle where the epithelium consists almost entirely of gland cells.

One type of cell stains blue in Mallory's triple stain, gives positive results with both alcian blue and the periodic acid–Schiff reaction, and shows gamma metachromasia with toluidine blue. The contents of these cells also exhibit a capacity to bind methylene blue at below *p*H 4, which indicates the presence of acid mucopolysaccharides[2]. The other type of mucous gland cell, which occurs approximately ten times more frequently than the other, stains red in Mallory's triple stain, exhibits a less-marked periodic acid–Schiff reaction, a faint reaction in tests for proteins, no staining in alcian blue, orthochromatic staining in toluidine blue, and binds with methylene blue at above *p*H 4. These results point to the presence of neutral mucopolysaccharides or of mucoproteins[2]. Two similar types of mucous cells have been described in the outer mantle epithelium of *Pinna*[1], but only a single type of cell comparable to that secreting a neutral polysaccharide in *Arca* is found in the outer mantle epithelium in many lamellibranchs, for example, *Anodonta cygnea*[3]. In this species, cells secreting an acid mucopolysaccharide are generally found on the inner surface of the outer mantle epithelium. In *Pinna*, Yonge[1] has observed that the mucous cells occur particularly in the outer mantle fold and suggests that they supply the necessary lubrication for the extensive withdrawal and re-extension of the mantle. The distribution of the gland cells in *Arca noae*, in which they are most plentiful proximal to the line of pallial attachment of the mantle, is not in accord with lubrication being a suitable explanation of their function in this species.

It has been suggested that the products of the mucous gland cells are concerned with the calcification of the valves[4,5]. No evidence of the presence of calcium in the mucous cells of *Arca* was, however, obtained by routine staining techniques. Incineration of sections at 600° C. in a manner similar to that used by Hedley[6] to detect calcium in a study of serpulid tube formation left a residue of white ash in the outer mantle epithelium, which gave characteristic crystals of calcium sulphate when treated with dilute sulphuric acid and a marked staining reaction with alizarin red[7]. This points to the presence of calcium in the outer mantle epithelium, particularly in the mucous cells. The absence of a staining reaction before incineration probably indicates that the calcium present may be bound to some organic substance, possibly the mucopolysaccharide, which inhibits normal staining reactions. An investigation of the secretion of calcium by the mantle epithelium of other lamellibranchs using the incineration technique is proceeding.

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Occurrence of *Crepidostomum metoecus* (Braun, 1900) in Britain

During the course of an investigation into the food and parasites of freshwater fishes in west Wales it was found that 74 per cent of 1,294 trout, *Salmo trutta* L., and 33·9 per cent of the 274 salmon parr, *Salmo salar* L., examined were infested with two species of *Crepidostomum*, namely, *C. farionis* (Müller) and *C. metoecus* (Braun). The parasites also occurred in one of the 243 eels, *Anguilla anguilla* (L.); but it is believed that the latter species constituted an accidental host.

The present record of *C. metoecus* in Britain is new. It has previously been recorded only in Austria[1], Sweden (=*C. suecicum* Nybelin, 1933)[2] and Ireland[3], and appears to have a more sparse geographical distribution than the allied species, *C. farionis*, which is known to have a circumpolar distribution.

The two species of *Crepidostomum* occurred together in the same host fishes, but there is some evidence of habitat isolation as *C. metoecus* occurred predominantly in the region of the pyloric cæca while *C. farionis* occupied a more posterior station in the intestine. Although *C. metoecus* is superficially very similar to *C. farionis* it may be distinguished from it by a consideration of the morphological features shown in Table 1. Certain of the differences, particularly those in the size of the body and the ventral sucker, may well be adaptations to the organ of the host infested.

Table 1. Differences between *C. metoecus* and *C. farionis*

Character	*C. metoecus*	*C. farionis*
Total length	0·87–2·12 mm.	1·52–5·02 mm.
Neck region	narrow	no distinct narrowing
Ratio of oral to ventral sucker	1 : 1·09–1 : 1·26	1 : 1·4–1 : 1·5
Oral papillæ	0·062–0·070 mm.	0·037–0·050 mm.
Pharynx	less than half length of oral sucker	more than half length of oral sucker
Gut cæca	narrow and short	wide and long
Excretory bladder	ends near anterior level of testes	extends in front of testes
Genital pore	behind gut bifurcation	in front of gut bifurcation
Vesicula seminalis	chambers overlapping	chambers in straight line
Vitelline follicles	small, occur dorsally and ventrally to gut cæca	large, occur ventrally to gut cæca
Number of eggs	rarely more than 30	up to 100
Space between ovary and anterior testis	narrow	wide

It is not unlikely that many of the early workers who described and recorded *C. farionis* have overlooked the possibility of a double infestation with the two *Crepidostomum* species. In this case *C. metoecus* may well prove to have a more widespread geographical distribution than has been hitherto suspected. A re-examination of the specimens of *Crepidostomum* studied by the earlier workers, particularly Dollfus[4] and Haderlie[5], seems desirable as certain aspects of their figures and descriptions of *C. farionis* appear to be atypical.

The two *Crepidostomum* species often occurred in large numbers in the alimentary canal of the salmonid fishes, and the average number of parasites per fish in one of the monthly samples was as high as 83·0. Although infestation in individual fish were heavy, no lesions attributable to these parasites were seen and they appear to be non-pathogenic. The degree of infestation was at a maximum during the winter months and at a minimum during the summer months. This seasonal variation could be attributed to a periodicity in the swarming of the cercariæ.

The trout were divided into age-groups and it was found that the older fish were more heavily parasitized by the two *Crepidostomum* species than the younger fish, the differences in the degree of infestation being significant at the level of 0·1 per cent. There is thus no evidence that trout develop an age resistance or an acquired immunity to the *Crepidostomum* species.

I am indebted to the Department of Scientific and Industrial Research for financial aid in connexion with this investigation, a more complete account of which will be published elsewhere.

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Calcium Requirements of *Azotobacter*

Although there have been a number of observations on the calcium requirements of individual species of *Azotobacter* they have concerned, almost exclusively, *A. vinelandii* and *A. chroococcum*[1,2]. It has been generally agreed that calcium is essential for the growth of *Azotobacter* with free nitrogen but some controversy exists regarding its necessity for growth on combined nitrogen. Several authors have claimed that it is not needed for growth on nitrate or ammonia[3] but others[3] have failed to confirm this. Burk and his co-workers[4] found it to be unnecessary in the presence of combined nitrogen, but later[5] reversed this opinion, stating that equal amounts of calcium were required for growth in the presence and in the absence of fixed nitrogen.

Much of the earlier confusion probably arises through the use of unsuitable media and through failure to effect an adequate removal of calcium during their preparation. In the present investigation the basal medium had the following composition (per cent): glucose, 2·0; potassium monohydrogen phosphate, 0·1; magnesium sulphate, 0·02; ferrous sulphate, 0·005; sodium molybdate, 0·0005. Chemicals of analytical-reagent grade and distilled water purified by ionic exchange were used throughout. All glassware was cleaned with hot nitric acid and carefully rinsed first with ordinary and then with purified distilled water. The glucose and the phosphate were dissolved together and the solution shaken with activated charcoal ('Norite') before addition of the other constituents. The medium was dispensed in 25 ml. amounts in 300-ml. Erlenmeyer flasks, calcium or strontium being added as required in the form of the chlorides. The flasks were plugged with cotton-wool and autoclaved at 110° C. for 15 min. Control experiments showed that the basal medium was deficient only in calcium ion.

Table 1. Nitrogen Fixed (mgm./25 ml.) during Growth on Free Nitrogen

Species (strain)	Calcium ion (p.p.m.)						
	20	10	4	2	1	0·4	0
A. vinelandii (0)	4·03	3·87	3·49	2·47	2·00	1·73	0·14
A. chroococcum (210)	6·11	5·92	6·00	5·31	4·35	3·22	0·09
A. beijerinckii (*L.H.*1)	6·33	5·35	4·65	1·97	0·27	0·12	0·05
A. insigne (*V.J.*)	6·84	6·85	6·28	5·52	4·03	1·05	0·08
A. macrocytogenes (*L.H.*2)	4·74	4·86	4·93	4·90	4·64	4·60	0·54
A. agile (*V.J.*)	7·95	7·83	7·85	7·82	7·42	7·04	6·79

Flasks were inoculated with one drop of a thin suspension of cells grown for two days on nitrogen-free calcium-deficient glucose agar, and the cultures were incubated at 25° on a rotary shaker. Good growth was normally obtained in 48 hr.; nitrogen was then determined by the Kjeldahl method.

In the absence of fixed nitrogen, calcium was essential for the growth of *A. vinelandii* (4 strains), *A. chroococcum* (4 strains), *A. beijerinckii* (2 strains), *A. insigne* (2 strains) and *A. macrocytogenes* (1 strain). It was not essential for *A. agile* (5 strains) although it had a more-or-less stimulatory effect. Typical results are presented in Table 1.

One strain of each of the species requiring calcium was tested for ability to utilize strontium; in each case it was found that this element could replace calcium at approximately the same molar concentration.

Table 2 shows the results of typical experiments in which nitrogen was provided as ammonium acetate at a concentration of 0·03 *M*. One strain of each of the species requiring calcium for growth on free nitrogen was tested for its ability to dispense with this cation when provided with fixed nitrogen. In each case calcium was needed at approximately the same concentration for growth with free and fixed nitrogen. Except for the non-essentiality of calcium for *A. agile* these results tend to corroborate the findings of Burk and Horner[5].

Table 2. Cell Nitrogen (in Washed Deposit mgm./25 ml.) produced during Growth on Ammonium Acetate

Species (strain)	Calcium ion (p.p.m.)						
	20	10	4	2	1	0·4	0
A. vinelandii (0)	6·88	6·82	6·11	5·83	3·66	1·73	0·10
A. chroococcum (210)	7·12	—	6·14	5·21	—	—	0·08

A more detailed report of this work will be published elsewhere.

One of us (J. R. N.) is indebted to the Yorkshire Agricultural Society for a Travelling Fellowship.

Note added in proof. On prolonged incubation in basal medium, *A. macrocytogenes* fixed some nitrogen in the complete absence of calcium, for example, 3·2 mgm./25 ml. after 7 days incubation at 25° C.

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A Physiological Effect of Triethanolamine on the Development of *Sclerotium rolfsii* (Sacc.)

Since triethanolamine was found to be an excellent emulsifier[1] it has been widely used in this capacity and also as an esterifying substance for plant regulators and herbicides of low solubility[2,3].

In work (unpublished) carried out in this laboratory the triethanolamine salt of maleic hydrazide was found to effect abscission of olive leaves more severely than the sodium salt of this substance at equal concentrations. Similar results were obtained with 2,4-D and MCP[4]. As a result of these observations it was decided to study its independent influence on biological processes. Such an investigation seemed particularly desirable in view of the wide use of triethanolamine as a solvent for growth substances.

The effect of triethanolamine was studied on *Sclerotium rolfsii* (Sacc.) grown on potato dextrose agar[5] containing increasing concentrations of the substance. The effect was determined by measuring the diameter of cultures at constant time-intervals, and by determining the first appearance and total of new sclerotia.

The appearance of new sclerotia on the medium is delayed at the higher concentrations and their total number is reduced (Table 1). No germination of sclerotia took place at concentrations in excess of 2,000 p.p.m. triethanolamine in the media.

No significant influence of triethanolamine on the rate of growth of the mycelia was noted. However, when germination of the sclerotia did occur, it was delayed and slowed up. By planting normal mycelia on a media containing a concentration of triethanolamine as high as 3,840 p.p.m. the mycelium still developed into normal cultures, the final amount of new sclerotia was somewhat lower.

Table 1. The Effect of Triethanolamine on the Development of *Sclerotium rolfsii*

Triethanolamine Concentrations in p.p.m.	Culture Diameter after 4 days (mm.)	Sclerotia	
		First appearance (days)	Total No. formed
0	78	5	388
120	69	5	378
240	60	5	360
480	53	5	334
960	15	7	230
1,920	0	11	190
3,840	0	nil	0

The effect of triethanolamine on *S. rolfsii* seems to be primarily a fungistatic one; when sclerotia which failed to germinate after 8½ days on media containing high concentrations of triethanolamine (3,840 p.p.m.) were transferred to control media, they developed into normal cultures but for a slightly lower production of new sclerotia in comparison to the control cultures.

The effect of triethanolamine on the germination of the sclerotia and the development of new ones in *S. rolfsii* seems to be rather specific. These effects appear to be somewhat independent from general growth reactions for the rate of growth of the mycelia after full germination of the sclerotia was not affected.

This leads to the conclusion that triethanolamine is not an inert solvent as commonly presumed[2,3], but rather has a definite effect at least, on the physiology of *S. rolfsii*.

A more detailed paper will be published elsewhere.

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A Die-back of Cacao Seedlings in Nigeria caused by a Species of *Phytophthora*

In September 1954 a die-back disease was seen on cacao seedlings growing in Agricultural Department nurseries established in various localities of the western region of Nigeria. There is no previous record of this disease in Nigeria, but it has reappeared in the nurseries in subsequent years. The disease caused considerable losses in these years, and in a particular nursery as many as 70 per cent of the young seedlings were killed. A species of *Phytophthora* has been established as the causal agent, and when inoculated into healthy cacao pods the symptoms produced were identical to those of black-pod disease caused by *Phytophthora palmivora* (Butl.) Butl.

The symptoms of this cacao seedling disease are similar to those caused by *P. palmivora* in Costa Rica[1] and in Surinam[2]. However, in these territories this pathogen also attacks the leaves and stems of mature cacao trees, whereas in Nigeria, except for the observations of Thorold[3] on the production of sporangia on cacao tree chupons following artificial inoculation, there is no evidence of *P. palmivora* affecting any part of the cacao seedling or the mature tree other than the pods.

In Nigeria the initial symptom is a brown discoloration of the tip of one or more of the leaves of the seedling. 1–2 days later, first the petiole blackens and wilts, and then the upper part of the stem. The discoloration frequently spreads down to the cotyledons, and at this stage the upper part of the stem may collapse due to necrosis. The disease may usually be detected about 17 days after germination, and the seedlings appear to be highly susceptible for a further period of 17 days. Seedlings which have escaped infection for a period of 42 days from

time of germination are rarely attacked afterwards. If the necrosis does not extend to the cotyledons, the seedling may recover due to the development of axillary buds. This type of recovery occurs among plants infected towards the end of their period of susceptibility, that is, 5–6 weeks after germination, and particularly when dry conditions prevail during the period immediately following infection.

Sporangia generally appear on the petiole and upper part of the stem 5–6 days after infection, although in a few instances they have been observed after 4 days. The pathogen produces sporangia in culture on potato dextrose agar similar to those of *P. palmivora*, but of smaller dimensions. It is thought that the causal agent of seedling die-back may be a form of *P. palmivora*; but isolates are at present being examined at the Commonwealth Mycological Institute with the view of specific identification.

A large measure of control (95 per cent) has been achieved using a proprietary copper fungicide. However, it was necessary to spray at frequent intervals (3 or 6 days) as only a low level of control was obtained with less-frequent (9 or 12 days) applications. The control experiments are being continued and will be fully reported elsewhere.

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A New Technique for the Study of Laboratory Populations of *Drosophila*

Investigation of the relationships between population size and gene frequency in laboratory studies of *Drosophila* have been limited to small breeding groups (usually of less than one thousand individuals) because of the difficulty of estimating population number. Direct counts can be made when units of the types described by Reed and Reed[1] and Buzzati-Traverso[2] are in use, but the environment in these systems lacks constancy. The former has been modified[3,4] for work on larger populations; but with this design there remains the possibility that migration between sections of the cage might be somewhat restricted. For that reason it was felt that the following technique might be of interest to other workers in this field.

The cages in operation at the present time (Fig. 1) are constructed of light gauge galvanized iron. Three rectangular section wire mesh channels which carry the food dishes run lengthwise between the doors at either end. The bottom of the cage is formed by an inverted pyramid terminating beneath in a screw connexion fitting a small opaque glass jar. Ventilation is provided by wire gauze panels in the sides. The top is of glass. The covers of the feeding ports are secured by wing-nuts, cork gaskets ensuring that they fit tightly against the cage.

Discarded food dishes are removed from one end of the cage as the fresh ones are pushed in at the other, each dish remaining in the cage for a time considerably in excess of the life-cycle of the flies. One, two or three food channels are used in the cage according to the population density required. Channels not in use for food carry dishes containing cellulose tissue

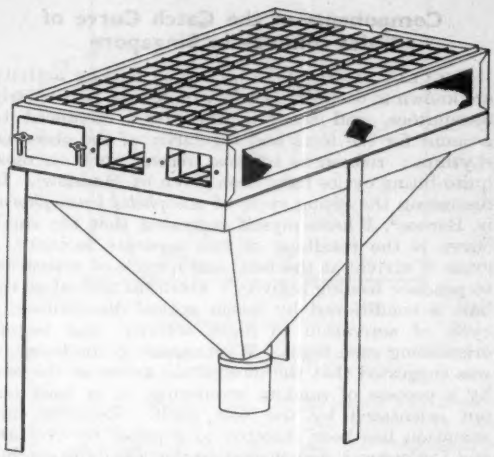

Fig. 1. The population cage (axometric projection)

soaked in water so that comparable humidities are maintained in all cages. Uniformity of humidity within the units is ensured by reversing the direction of movement of the food or water dishes along alternate channels.

Population counts are made fortnightly. Debris is first dislodged by tapping, and the glass jar fitted to the bottom of the cage is cleaned out. Carbon dioxide is then admitted, achieving almost instantaneous anæsthesia, and the flies drop into the jar. Any lodged in crevices or on the surfaces of the food dishes are removed by the blast of gas. The jar is unscrewed from the cage and the flies are shaken out evenly on to sheets of 'Kodagraph' contact copying paper in the darkroom and a brief exposure made. Random samples are taken for scoring gene frequencies, and are returned to the cage with the rest of the population. Provided that the flies are well spread out during the few minutes needed for recovery, there is no mortality. As the flies are readily distinguishable from any debris which may have fallen into the collecting jar with them, the determination of population size is made directly from the photographic record.

Food dishes and adult flies may be transferred to a clean cage as this becomes necessary. In the event of mite infestation, monthly transfers afford satisfactory control, eliminating the use of chemical deterrents[5] of doubtful safety.

In the experiments being conducted in cages of this type, the growth of the population is at first rapid and oscillation of size extreme. These fluctuations continue about an equilibrium density but, over the present experimental period, gradually decrease in amplitude. Population growth and the rate of elimination of marker alleles depend upon the genetic heterogeneity of the population as well as on its size. The results of this work will be reported in detail elsewhere.

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Components of the Catch Curve of *Culex annulus* in Singapore

Regular cycles of flight and/or feeding activity are known to occur in a variety of insects, particularly mosquitoes, and theories have been advanced to account for the form and regularity of the observed rhythms; references to most recent work on mosquito-biting cycles have been given by Haddow[1]. In discussing the biting cycle of *Anopheles leucosphyrus* in Borneo[2], I have myself suggested that the catch curve is the resultant of two separate factors: a cycle of arrival at the bait, and a cycle of activation to produce feeding activity; also that arrival at the bait is conditioned by initial spatial distribution, a cycle of activation to flight activity, and factors orientating such flight. With regard to the latter, it was suggested that the mosquitoes arrive at the bait by a process of random wandering, or at least one not orientated by the bait itself. Recently, my attention has been directed to a paper by Webster and DeCoursey[3], demonstrating that the daily catches in a variety of arthropods are in fact determined by a process of random arrival at the trap, in accordance with a theoretically derived equation of the form:

$$\log (K - C) = a + bt$$

where K is the initial population, C the cumulative catch, t time, and a and b are constants.

Further information has now come to hand from investigations of biting cycles in certain Singapore mosquitoes, particularly the nocturnal *Culex annulus*. All-night catches were made from a horse confined in a mosquito-proof stable; the door was left open and mosquitoes entering were collected by hand at ½-hr. intervals. *C. annulus*, like most Malaysian mosquitoes, rests near the bait for a significant period before feeding, and almost all were taken while resting unfed on the walls. The observed cycle thus represents arrival at the bait, rather than an actual biting cycle. The combined results of 27 catches, totalling 1,807 mosquitoes, are shown in Table 1 and Fig. 1, which show the mean hourly catches throughout the period of activity, using local standard time; means are arithmetic since there was little variation in the nightly catches. If cumulative hourly totals are calculated as in Table 1, and plotted as in Fig. 2, they are found to conform closely to a curve of the type derived by Webster and DeCoursey[3]. In this case, the constant K, derived graphically, has a value of 110.

This is, in fact, the expected curve of mosquitoes arriving at the bait by random wandering in a closed domain, when the rate of arrival is proportional to the number remaining uncaught, that is:

$$\frac{dC}{dt} = k(K - C) \quad (k, \text{ the 'catch rate'})$$

Thus, by rearranging and integrating:

$$\log (K - C) = a + bt$$

The close agreement of the observed catches with the theoretical equation suggests strongly that in this case the mosquitoes were arriving in the near vicinity of the bait by some random process, or orientated by variable influences which tended to become randomized over a long series of catches.

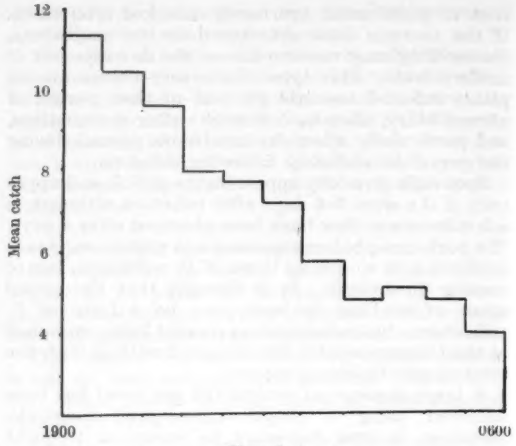

Fig. 1

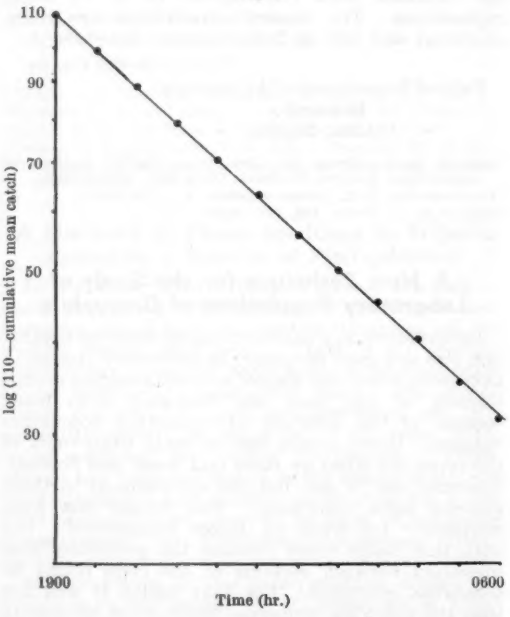

Fig. 2

Presumably their initial distribution was fairly uniform and activation to flight activity more or less immediate upon the onset of darkness. The steady fall in the curve of Fig. 1 thus represents nothing more than the depletion of the population of unfed mosquitoes by their fixation at the bait, and will normally be a composite effect of the numerous baits present within the 'closed domain', the latter being delimited by geographic features.

It should be noted that the actual biting cycles of most *Culex* species, and *Mansonia* species, in Singapore are of the same general type as shown in Fig. 1, and it seems probable that the biting cycles of most

Table 1. Mean Hourly Catches of *Culex annulus*

Hour ending	2000	2100	2200	2300	0000	0100	0200	0300	0400	0500	0600
Mean catch	11·3	10·4	9·6	7·9	7·7	7·2	5·7	4·8	5·1	4·3	4·0
Cumulative mean catch	11·3	21·7	31·3	39·2	46·9	54·1	59·8	64·6	69·7	74·5	78·5

mosquitoes include, as one component, a 'depletion curve' of the type described. The more distinctive features of such cycles are presumably effects of other components, such as the cycles of activation to flight and feeding activity.

My thanks are due to the Singapore Turf Club for assistance when making the above catches, and to Mr. R. Guy for mathematical advice.

DONALD H. COLLESS

Department of Parasitology,
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Singapore.

[1] Haddow, A. J., *Nature*, **177**, 531 (1956).
[2] Colless, D. H., *Trans. Roy. Ent. Soc. Lond.*, **108**, 37 (1956).
[3] Webster, A. P., and DeCoursey, J. D., *Ann. Ent. Soc. Amer.*, **47**, 178 (1954).

Speech Production and Language Statistics

THE purpose of the experiment reported here was to examine the function of hesitation pauses in speech. Pauses were conceived of as serving the selection processes which direct the course of verbal sequences, and as involving acts of choice. They were expected to occur where linguistic solutions fitting the speech intentions are not readily available, or where automatic verbalization is rejected in favour of 'newer', more specifically selected verbal expression.

Speech being a Markoff process, that is, a sequence of symbols the selection of which is determined by previous choices, each successive symbol is chosen according to the transitional probabilities, which depend at any stage on preceding choices as well as on the particular symbols themselves. At such stages where the probability of choice is less dependent on the previous choices, the speaker is said to have greater freedom of choice. Pauses in speech (within sentences) were expected to occur at these stages. The words following pauses were therefore expected to show a decrease in transitional probability, or predictability, and in that sense carry an increase of information.

This hypothesis was tested by relating the incidence of pauses interrupting the smooth utterance of sentences in spontaneous speech to the transition probabilities of the words constituting them. Estimates of these probabilities were obtained experimentally by an adaptation of Shannon's[2] technique used in the prediction of printed English. Instead of guessing sequences of letters, subjects were asked to guess each successive word in a sentence which had been uttered in recorded spontaneous speech. The details of the experiment will be described elsewhere.

There were two series of experiments. In the first, subjects were asked to start guessing the first word and continue one by one to the last. Seven sentences containing 212 words and 34 pauses were predicted in this way.

In the second set of experiments a new set of sentences (136 words and 26 pauses) was subjected to predictions in reverse direction, starting with the last word and working backward, as well as those in the forward direction. The validity of the transitional probabilities was considerably increased by estimating them on the basis of the combined and averaged forward and reverse guesses.

Fig. 1 (summarizing the results of the second series of experiments) shows the probability distributions for the 26 words which followed pauses and for the 110 words which were uttered without a break.

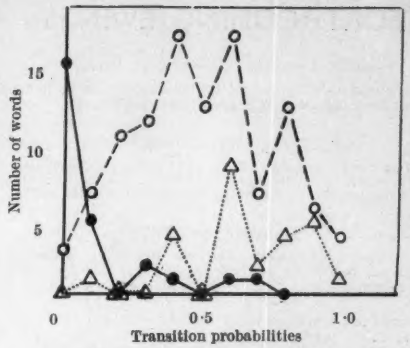

Fig. 1. O---O, words uttered fluently; ●——●, words following pauses: △·····△, words preceding pauses

The probability distribution for the words which preceded pauses is also shown. The differences are highly significant ($P < 0.001$) and the relationship between pauses and transitional probabilities shows that redundancy in language is as closely associated with fluency of utterance as uncertainty of prediction with hesitancy. The hypothesis that pauses in speech function as precursors of sudden increases of information has been borne out by the facts. A measurable link seems thus to be established between objective language on one hand and the subjective aspects of speech behaviour on the other.

This research is being carried out at the Phonetics Department, University College, London, under a grant from the Medical Research Council. I am indebted to Dr. B. B. Fry and the staff of the Phonetics Department for their collaboration in the experiments and for much stimulating discussion.

F. GOLDMAN-EISLER

Department of Phonetics,
University College,
London, W.C.1.

[1] Hughlings, Jackson, "On Affections of Speech from Disease of the Brain", Selected Writings, 2 (London, 1932).
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Duration of Spermatogenesis in the Mouse

I AM glad that the major points of my communication[1] apparently have been accepted by Sirlin and Edwards[2], and especially that they now state "that preleptotene spermatocytes were initially labelled by adenine" instead of their original statement[3] that 'The initial labelling of deoxyribonucleic acid with adenine takes place only in spermatogonia . . .". Thus the labelling is now placed at the initiation of meiosis. This confusion is another example of the result of misclassification of the products of the fifth spermatogonial division as spermatogonia. As emphasized in my communication[1], such errors in classification can be avoided by using the techniques developed by Leblond and Clermont[4] and extended by me to the mouse[5].

E. F. OAKBERG

Biology Division,
Oak Ridge National Laboratory,
Oak Ridge, Tennessee.

[1] Oakberg, E. F., *Nature*, **180**, 1137 (1957).
[2] Sirlin, J. L., and Edwards, R. G., *Nature*, **180**, 1138 (1957).
[3] Sirlin, J. L., and Edwards, R. G., *Nature*, **179**, 725 (1957).
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[5] Oakberg, E. F., *Amer. J. Anat.*, **99**, 391 (1956).

FORTHCOMING EVENTS

Tuesday, December 31—Friday, January 3

GEOGRAPHICAL ASSOCIATION (at the London School of Economics, Houghton Street, London, W.C.2)—Annual Conference.

Wednesday, January 1

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. M. B. Broadbent and Mr. G. A. Dickens: "Lubrication Problems Arising from Railway Traction Modernization".

Thursday, January 2

PLASTICS INSTITUTE (in the William Beveridge Memorial Hall, Senate House, University of London, W.C.1), at 2.30 p.m.—Prof. C. E. H. Bawn, F.R.S.: "The Progress of Plastics" (Young People's Lecture).

INSTITUTE OF REFRIGERATION (at the Junior Institution of Engineers, Pepys House, 14 Rochester Row, Westminster, London, S.W.1), at 5.30 p.m—Mr. W. F. Bews: "Properties, Handling and Storage of Modern Refrigerants".

Friday, January 3

SOCIETY OF COSMETIC CHEMISTS OF GREAT BRITAIN (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7.30 p.m.—Mr. D. F. Anstead: "Pigments, Lakes and Dyestuffs in Cosmetics".

Saturday, January 4

BRITISH INTERPLANETARY SOCIETY (in the Tudor Room, Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Dr. R. F. L. Boyd: "High Altitude Research during the International Geophysical Year".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

RESEARCH ASSISTANT (with the degree of Ph.D., or about to submit a Ph.D. thesis) IN THE DEPARTMENT OF CHEMISTRY, for work which involves carbonization of high-molecular weight compounds, graphitization of the resulting carbons, and examination of the physical properties of the product with particular emphasis on absorption studies—The Registrar, The University, Hull (January 4).

READER IN STRUCTURAL STEELWORK at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 6).

ASSISTANT EXPERIMENTAL OFFICER (with a pass degree or equivalent qualification) IN THE DEPARTMENT OF POTATO GENETICS, to assist in breeding potato varieties resistant to blight and to virus diseases—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford (January 11).

LECTURER or SENIOR LECTURER IN CHEMICAL PATHOLOGY in the Faculty of Rural Science, University of New England, Australia—The Registrar, University of New England, Armidale, N.S.W., Australia, or Dr. J. F. Foster, Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 15).

RESEARCH WORKER (with a veterinary diploma or degree) IN BOVINE INFERTILITY—The Registrar, The University, Bristol (January 17).

GEOLOGISTS (with an honours degree in geology requiring a four-year course at a recognized university, and preferably with previous experience) with the Southern Rhodesia Government—The Secretary (B), Rhodesia House, 429 Strand, London, W.C.2 (January 18).

ZOO-PLANKTOLOGIST (with a university honours degree in science, together with postgraduate experience in marine work, or equivalent qualifications, and preferably experience in planktological research) IN THE DIVISION OF FISHERIES AND OCEANOGRAPHY, Commonwealth Scientific and Industrial Research Organization, Sydney, New South Wales, Australia, to supervise, and to some extent take part in, the collecting and identification of zooplankton, and also to carry out research on zooplankton production and its ecological relationships—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 320/133 (January 18).

ELECTRICAL ENGINEER/PHYSICIST IN THE DEPARTMENT OF PHYSICS, to supervise the operation of a 6 MeV. van de Graaff machine, and to develop associated research equipment—Prof. Samuel Devons, The Physical Laboratories, The University, Manchester 13 (January 20).

SENIOR LECTURER or LECTURER IN THE DEPARTMENT OF PHYSIOLOGY, University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, January 20).

CHAIR OF EDUCATION in the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 27).

CHAIR OF BOTANY tenable at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 29).

ASSISTANT LECTURER (man or woman graduate) IN MATHEMATICS, preferably Applied—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (January 31).

CHAIR OF THEORETICAL PHYSICS in the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 34 Gordon Square, London, W.C.1 (South Africa, January 31).

DIRECTOR OF THE WELSH PLANT BREEDING STATION, Aberystwyth—The Registrar, University College of Wales, Aberystwyth (January 31).

LECTURER IN CHEMISTRY at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 31).

UNIVERSITY LIBRARIAN—The Registrar, The University, Nottingham (January 31).

READER IN ORGANIC CHEMISTRY at King's College—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 1).

READERS (2) IN MATHEMATICS, one in the field of pure mathematics and the other in the field of applied mathematics; a SENIOR LECTURER IN PURE OR APPLIED MATHEMATICS; and a LECTURER IN PURE or APPLIED MATHEMATICS, at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 28).

VISITING FELLOWS IN SCIENCE (2) (women graduates from the Commonwealth or the U.S.A.)—The Principal, Lady Margaret Hall, Oxford (May 1).

CHAIR OF PSYCHOLOGY—The Registrar, The University, Bristol.

ELECTRICAL/ELECTRONIC ENGINEER (with a professional qualification, and preferably an electrical engineering degree and experience of high vacuum or high frequency techniques, or of electro-mechanical plant), to operate and maintain a nuclear physics machine consisting of a 23-MeV. electron accelerator used to bombard uranium and so to produce intense neutron pulses for nuclear experiments—The Recruitment Officer (902.Y/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

INSTRUCTOR or ASSISTANT PROFESSOR (preferably with the Ph.D. degree or equivalent) IN THE DEPARTMENT OF MATHEMATICS—The Department of Mathematics, University of British Columbia, Vancouver 8, Canada.

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SENIOR LECTURER (with a good honours degree and A.R.I.C.) IN CHEMISTRY; and a LECTURER (with a degree in metallurgy and/or A.I.M.) IN METALLURGY—The Principal, Ipswich Civic College, Rope Walk, Ipswich.

SENIOR LECTURERS or LECTURERS IN MATHEMATICS, CHEMISTRY, CIVIL or MECHANICAL ENGINEERING, ELECTRICAL ENGINEERING, RADAR AND TELECOMMUNICATIONS, and ENGINEERING PHYSICS at the Royal Military College of Science, Shrivenham, Berkshire—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.364/7A.

SENIOR SCIENTIFIC OFFICER/SCIENTIFIC OFFICER (with a first- or second-class honours degree or equivalent in electrical engineering or physics, with experience in electronics) at the Ministry of Supply Aeroplane and Armament Experimental Establishment, Boscombe Down, Amesbury, Wilts, for work on electronic and electrical systems and development of test techniques and instrumentation for Service clearance of special armament stores—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.359/7A.

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National Association for Mental Health. 50 Questions and Answers on Mental Illness arising from the B.B.C. programmes "The Hurt Mind" and "To Comfort Always". Pp. 22. (London: National Association for Mental Health, 1957.) 1s. [309

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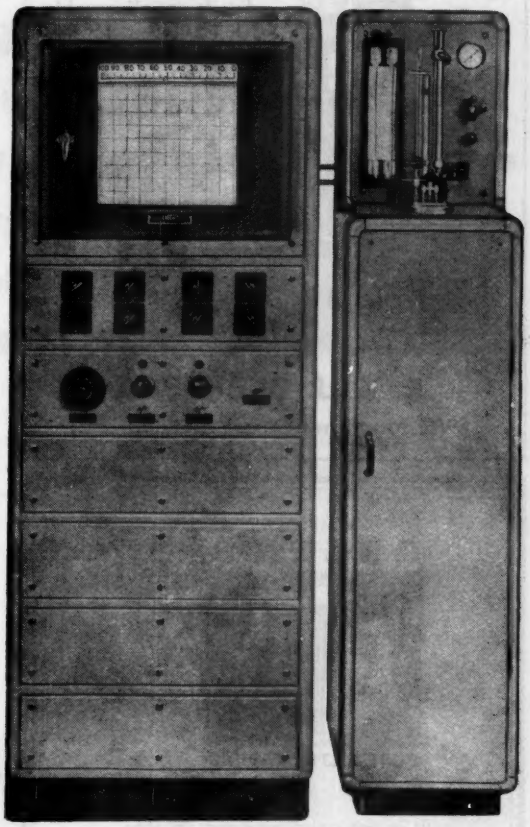

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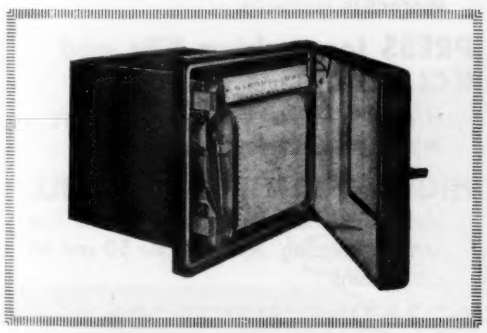

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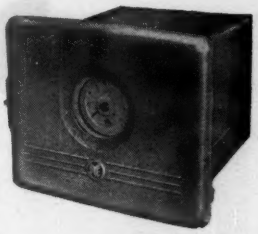

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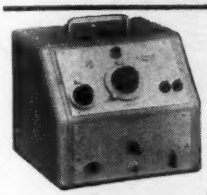

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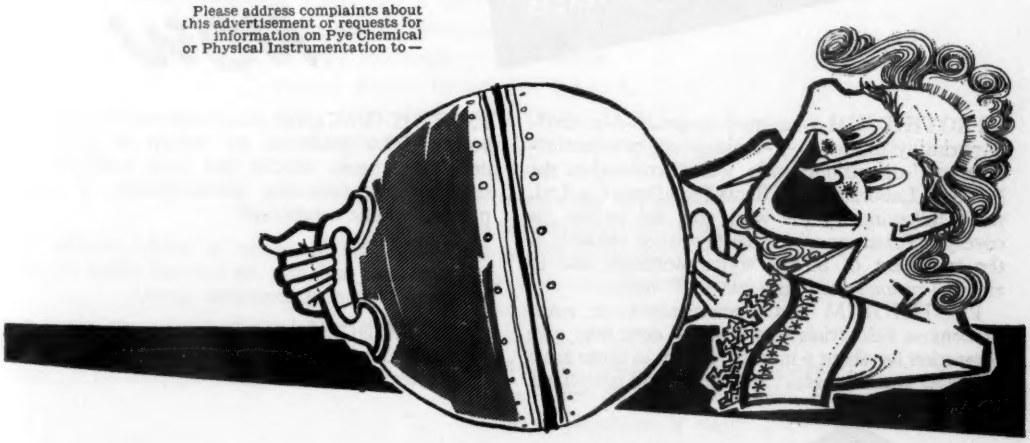

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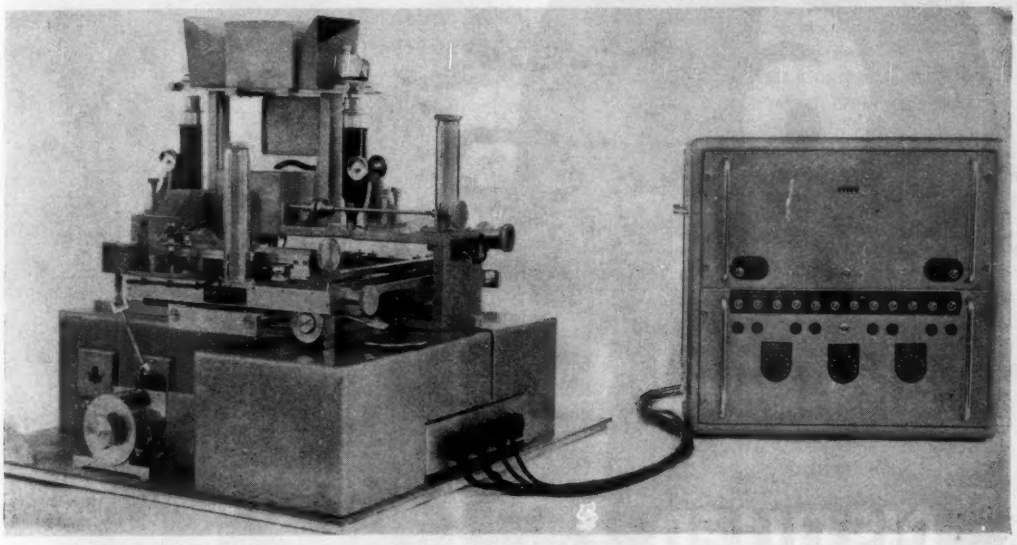

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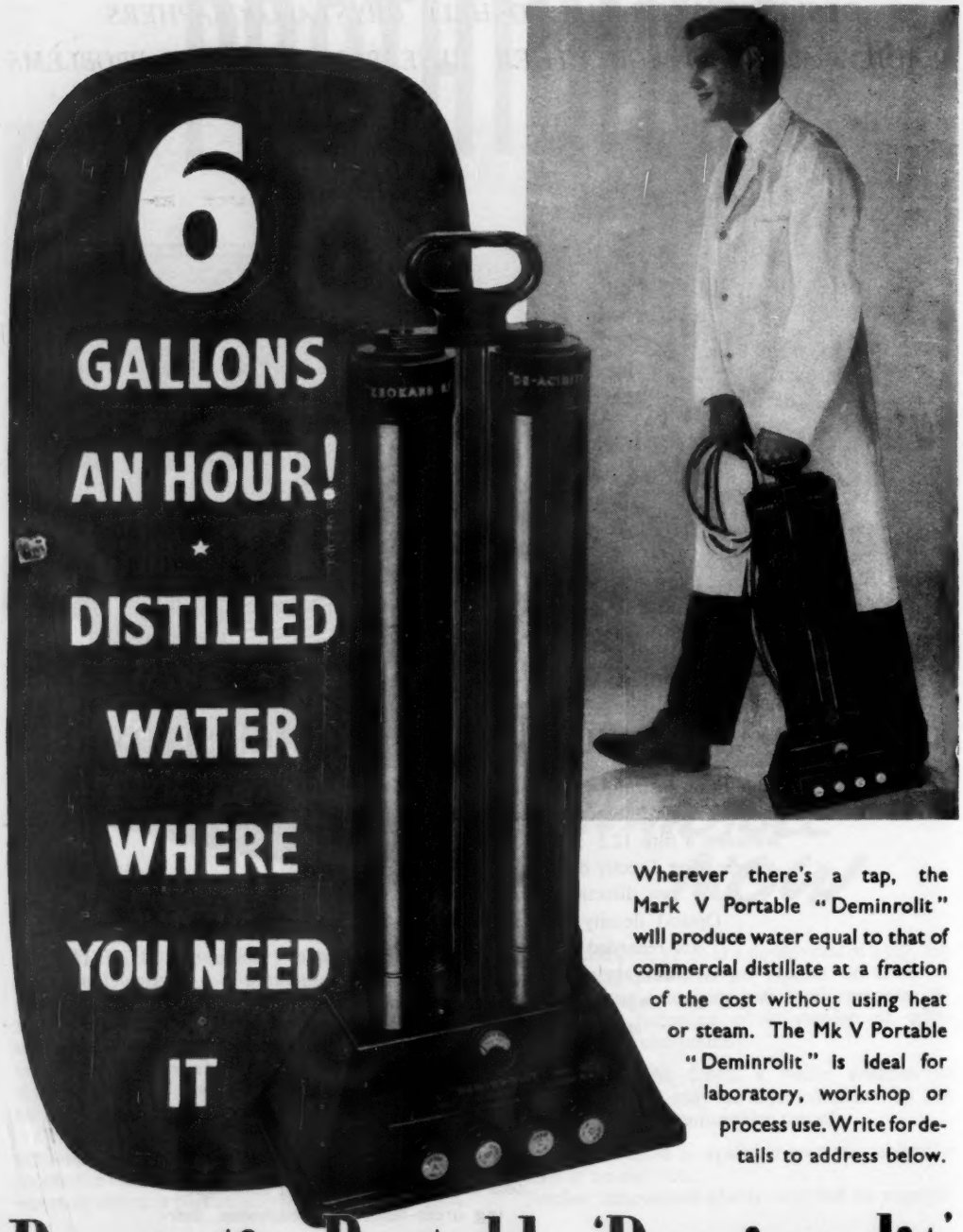

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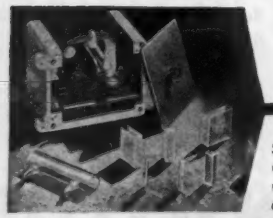

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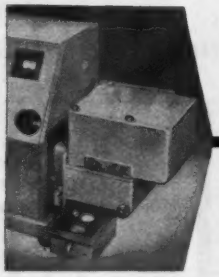

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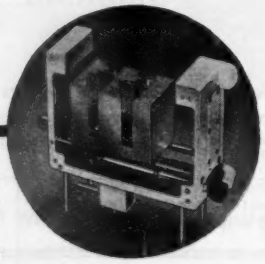

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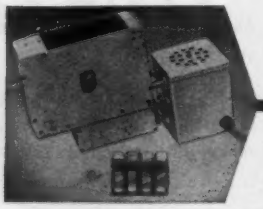

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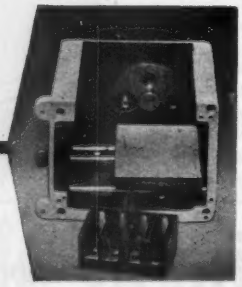

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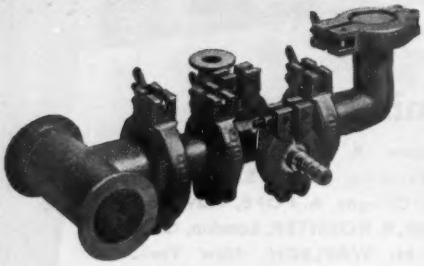

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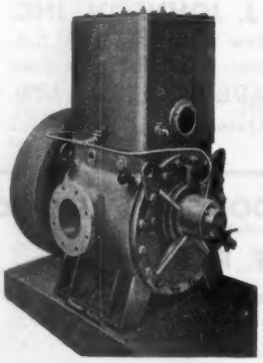

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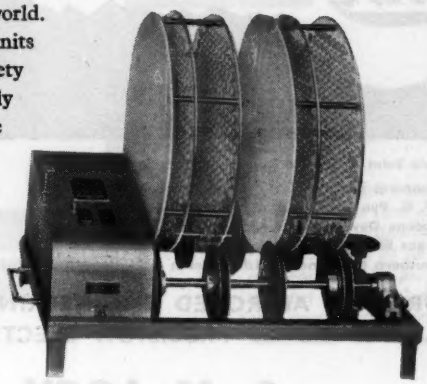

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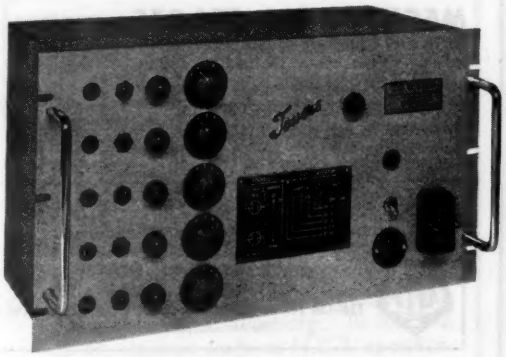

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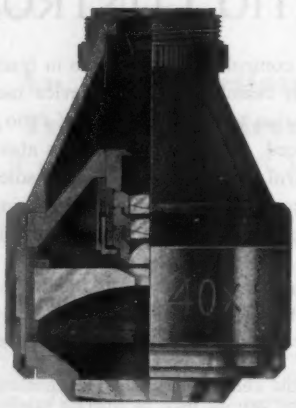

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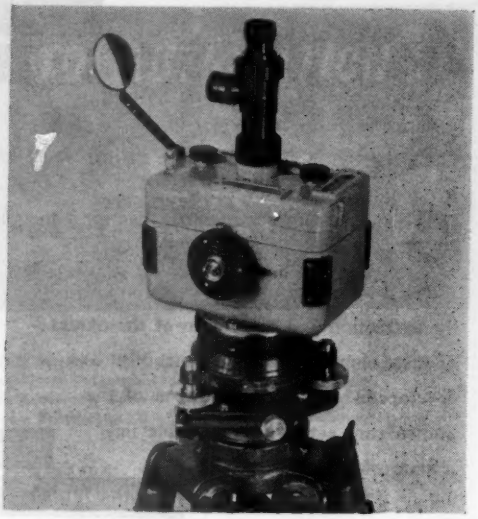

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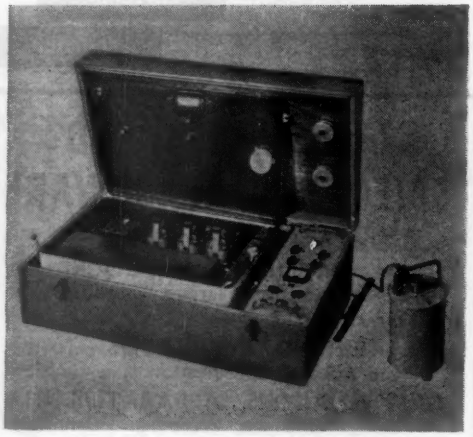
For full details write for catalogue CS 64/N 12



Willmore seismograph

For work over the 'near-earthquake' range. It is a short-period instrument for observatory or field use. The seismometer is highly sensitive, and the photographic recorder will resolve periods well under 0·1 second. The instrument equals or surpasses the performance of standard observatory types and is more strongly constructed and much simpler.

For full details write for catalogue CS 67/N 12

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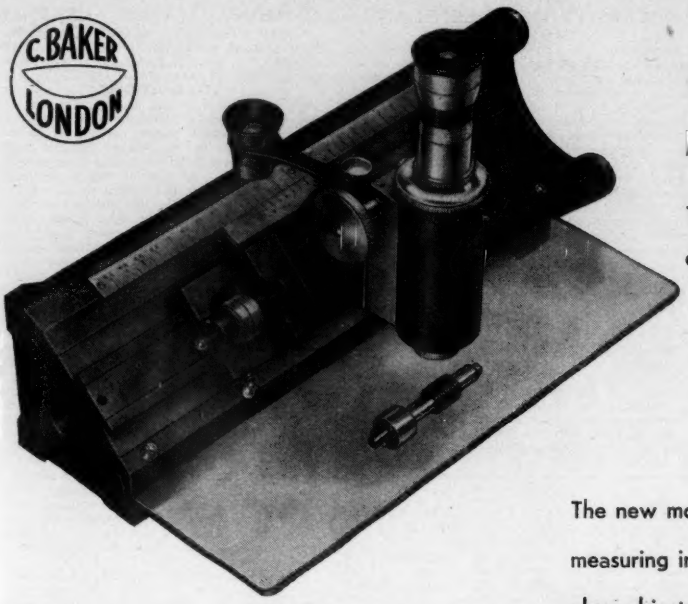

VERNIER MEASURING MICROSCOPE

Two models—0·001 in. or 0·05 mm.

The new model of this well-tried and versatile measuring instrument is provided with a robust glass object-table which can be removed when necessary by the release of two clamp screws

An illustrated folder showing some of the many uses of the microscope is available

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(Finance Act, 1956)

The "Old Equitable's" new participating plan gives the policy holder freedom to decide each year how much, within the terms of the Act, he will contribute as a premium. The Society pays no commission and therefore quotes exceptionally favourable terms.

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The Equitable Life Assurance Society

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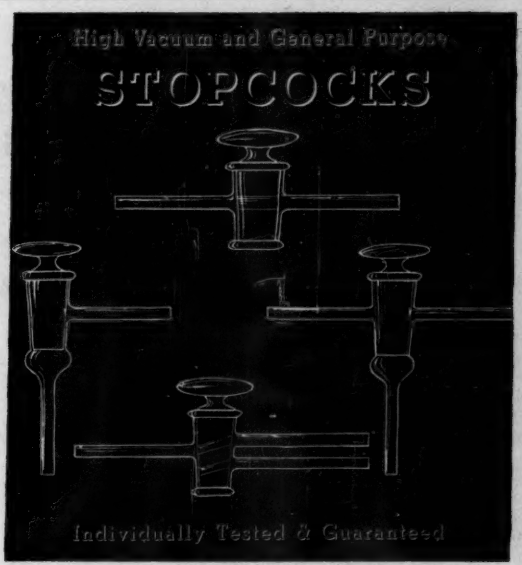

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"The Stopcock People"
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OFFICIAL APPOINTMENTS

ROYAL TECHNICAL COLLEGE
SALFORD

Principal: C. Whitworth, M.Sc., Ph.D., F.R.I.C., F.Inst.F.

LECTURING IN ENGINEERING

The designation of the College as a College of Advanced Technology, and the expansion of advanced work for full-time courses, results in a number of vacancies on the lecturing staff of the Department of Mechanical Engineering. The Department offers advanced courses in Mechanical, Production and Aeronautical Engineering up to honours degree level, and is moving into well-equipped laboratories in a new building early in 1958. Important developments are taking place in the Department and staff will be encouraged to participate in research and consulting work, and to develop contacts with industry and with other organizations. The generous leave, the personal and responsible nature of the work, and an atmosphere of academic freedom may appeal to engineers who have not hitherto considered lecturing as a possible career. Others may welcome an opportunity of returning to academic work for a period before returning to industry. The Governors of the College invite applications from suitably qualified persons with an honours degree, or equivalent, and in the case of Lecturers and Senior Lecturers, with teaching, industrial or research experience. The salary scales are as follows: Senior Lecturers (men), £1,350 to £1,550; Lecturers (men), £1,200 to £1,350; Assistants, Grade B (men), £650 to £1,025, plus approved teaching, graduate, training and industrial experience allowances.

Further particulars of the posts and forms of application may be obtained from the Principal, Royal Technical College, Salford, 5, to whom applications should be returned as soon as possible.

R. RIBBLESDALE THORNTON,
Clerk to the Governors.

UNIVERSITY OF BRITISH COLUMBIA

Applications are invited for an Instructorship or Assistant Professorship in the Department of Mathematics. Candidates should preferably hold the degree of Ph.D. or the equivalent. Salary ranges: Instructor, $4,500 to $5,500; Assistant Professor, $5,500 to $6,500.

Further particulars may be obtained from the Department of Mathematics, University of British Columbia, Vancouver 8, Canada.

UNIVERSITY OF QUEENSLAND
AUSTRALIA

Applications are invited for the position of Senior Research Officer in the Department of Mining and metallurgical Engineering. Applicants should be graduates in mining/metallurgical engineering from a recognized university, or with equivalent qualifications; they should have had research experience in milling and treatment problems. Experience with radioactive ores, though desirable, is not essential. The officer will be afforded an opportunity of enrolling for study leading to a higher degree. Salary £A.1,850 per annum.

Further particulars are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in Australia and London on February 15, 1958.

JOHN INNES HORTICULTURAL INSTITUTION

Assistant Experimental Officer required in the Department of Potato Genetics to asist in breeding potato varieties resistant to blight and to virus diseases. A pass degree or equivalent qualification is necessary. Salary £370 to £800 per annum according to age. Superannuation.

Applications, with full details and names of two referees, to the Secretary, Bayfordbury, Hertford, by January 11, 1958.

PHYSICISTS
CENTRAL ELECTRICITY AUTHORITY
RESEARCH LABORATORIES, LEATHERHEAD

PHYSICISTS required at the Laboratories for research into the non-destructive testing of all types of materials used in the Electricity Supply Industry. The work will consist of developing and applying techniques, rather than actual routine testing.

Candidates should have an honours degree or equivalent qualification. Experience in one or more branches of non-destructive testing will be a recommendation, but newly qualified applicants will be considered for the Grade 4 appointment.

Salary for the appointments will be within Grades 3 or 4 of the National Joint Board Agreement, i.e., £1,055 to £1,265 or £820 to £995 per annum.

Write for application form to D. Moffat, Director of Establishments, Winsley Street, London, W.1, to be returned by January 20, 1958. Quote Ref. N./514.

COMMONWEALTH of AUSTRALIA
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION
COMMONWEALTH RESEARCH STATION
APPOINTMENT NO. 490/67 OF RESEARCH HYDROLOGIST

Applications are invited for appointment to a position of Research Hydrologist with the Commonwealth Research Station located at Merbein, Victoria. Work at the Station includes fertility studies and research into soils and their behaviour under irrigation. As part of this programme, a Research Hydrologist is required to undertake investigations on the principles involved in the application of irrigation water to land and on problems of groundwater hydrology. Applicants should have a university honours degree in engineering, agricultural engineering or science with physics as major subject or equivalent qualifications and with research experience in one or more of the fields of soil physics, meteorology, hydraulics and groundwater hydrology. Commencing salary is dependent upon the appointee's qualifications and experience and will be determined within the salary ranges of Research Officer or Senior Research Officer, £A.1,313 to £A.1,938 per annum, or £A.2,048 to £A.2,323 per annum. Salary for a female appointee would be £A.167 per annum less than the corresponding male rates quoted. The appointment will be conditional upon a satisfactory medical examination and the appointee may be required to serve for an initial probationary period of up to twelve months before being confirmed in his appointment as an Officer of the Organization. If so confirmed he will be required to contribute to and eligible to receive benefits from either the Commonwealth Superannuation Fund or the Commonwealth Provident Account.

Applications, quoting Appointment No. 490/67, and stating full name, place, date and year of birth, nationality, marital state, present employment, particulars of qualifications and experience, and of war service, if any, accompanied by copies of not more than four testimonials, and the names and addresses of three professional referees, should reach the undersigned, from whom further particulars may be obtained, by January 25, 1958.

A. SHAVITSKY,
Chief Scientific Liaison Officer.
Australian Scientific Liaison Office,
Africa House, Kingsway, London, W.C.2.

UNIVERSITY COLLEGE OF GHANA

Applications are invited for the Chair of Chemistry. Salary £2,400 per annum. Family allowance £100 per annum per child (maximum £500 per annum). Outfit allowance £60. F.S.S.U. Passages for appointee, wife and maximum of five children, on appointment, normal termination and leave. Part-furnished accommodation at rent not exceeding 7.5 per cent of salary.

Detailed applications (six copies), naming three referees, by January 31, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY OF MANCHESTER
MICRO-ANALYST

There is a vacancy in the Organic Laboratories of the Department of Chemistry for a Micro-Analyst. The appointment will be made in the Senior Technician grade. Salary within the range £590 to £690 per annum, with membership of a Superannuation Scheme.

Applications should be sent to the Chief Technician, The Department of Chemistry, The University, Oxford Road, Manchester, 13.

D.S.I.R. ROAD RESEARCH LABORATORY, Harmondsworth, Middlesex, requires Chemists for research on use and performance of bituminous road materials and on problems arising from presence of organic matter in soils. Varied and interesting work carried out in laboratory and field providing satisfying sense of achievement in solving the many problems involved; also contacts with other research chemists, physicists, engineers, mathematicians and practising chemists at home and abroad. Posts in Scientific Officer or Senior Scientific Officer grades requiring first- or second-class honours in chemistry or equivalent. For Senior Scientific Officer posts some research experience necessary. Salary range £615 to £1,370. Women's pay slightly less, equal pay scheme. Normal prospects of promotion to Principal Scientific Officer (range up to £2,000 per annum with possibilities of higher posts). Opportunities for early establishment with superannuation. Five-day week.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.647/7A.

THE CHARLES G. WILLIAMS FELLOWSHIP
IN
URANIUM METALLURGY
1958-1959

Eldorado Mining and Refining Limited invites applications for a post-graduate scholarship in Uranium Metallurgy, known as The Charles G. Williams Fellowship.

This fellowship, which is renewable and valued at $1,500 for an academic year, may be awarded to a graduate in the physical sciences, pure or applied. A cash grant to the University concerned, to cover expenses used in the research project, will accompany the granting of the fellowship.

A student awarded this fellowship will also be eligible for a supplementary amount of $800 for the summer months following the academic term, provided he works at his University or at an Institute acceptable to Eldorado Mining and Refining Limited and his research supervisor.

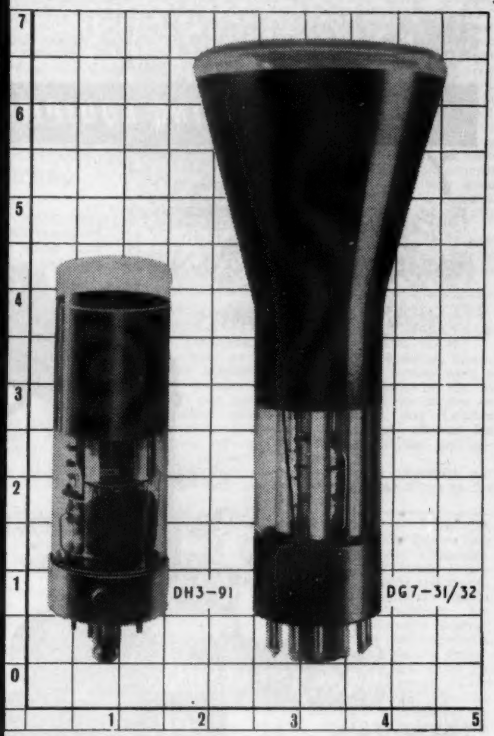
Copies of Regulations governing this award and application forms may be obtained from:

The Secretary,
Eldorado Mining and Refining Limited,
P.O. Box 379, Ottawa, Ontario,

to whom applications must be submitted by March 15, 1958.

Mullard

Low Voltage Cathode Ray Tubes



DH3-91

Low voltage operation

The DH3–91 will operate at voltages as low as 350V. A new screen process allows the tube to be operated at this unusually low voltage without the disadvantages of screen charging effects.

Automatic beam focusing

The useful screen diameter is one inch and no focus potentiometer is required. The extremely simple circuit requirements of the DH3–91 together with its very short length of only 4¼ inches (max.) make possible the provision of economic monitoring facilities in a wide variety of applications. Full data and circuit information are available on request.

Heater 6.3 volts, 0.55 amp.
Typical Operation

Va1+a3	500V
Vg	–8 to –27V
Sx	0.19 mm/V.
Sy	0.22 mm/V.

DG7-31/32

DG7–31 (*Asymmetrical Deflection*)
DG7–32 (*Symmetrical Deflection*)

In applications where more detailed information is required than can be provided by the one-inch DH3–91, such as in larger oscilloscopes or in the monitoring of more complex waveforms, the three-inch diameter DG7–31 and DG7–32 are outstanding. The screen phosphor is burn-resistant and the tubes will operate with a final anode voltage of 400V. Both the DG7–31 and DG7–32 are only 6¾ inches long.

Heater 6.3 volts, 0.3 amp.
Typical Operation

Va1+a3	500V
Va2	0 to 120V
Vg	–50 to –100V
Ia2	–15 to + 10μA
Sy	0.39 mm/V
Sx	0.25 mm/V
Line width (measured on a circle of 50 mm diameter with Va1 + a3 = 500V and It = 0.5μA)	0.5 mm

MVT 320d

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MULLARD HOUSE
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COMMONWEALTH of AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION DIVISION OF PLANT INDUSTRY APPOINTMENT NO. 130/324 OF ELECTRONICS ENGINEER

The Division of Plant Industry is concerned with research into many aspects of agriculture and biology basic to the continued development of Australian primary industry. Its research programmes in biochemistry, biophysics, physiology, ecology, micro biology and other fields, both in the laboratory and the field, offer considerable scope for the application of electronic principles and for collaborative research in the electronics field. Applications are invited from graduates interested in this field, to establish an electronics laboratory within the division at Canberra. The appointee will be required to initiate research into the application of electronics to problems of agricultural research. Applicants should possess a university honours degree in science or engineering and have had research experience in the fields of instrumentation and applied electronics. Dependent on qualifications and experience, commencing salary will be determined within the ranges of Senior Research Officer, £A.2,048 to £A.2,323 or Research Officer, £A.1,313 to £A.1,938. The appointment may initially be for a period of three years, although an indefinite appointment would be considered. Appointment will be conditional on a satisfactory medical examination. If appointment is made on an indefinite basis the position will carry superannuation fund or provident account privileges. In the case of an appointee domiciled overseas, first-class sea fares to Australia will be paid for the appointee, his wife and family. If the appointee does not take up an indefinite appointment with the Organization at the expiry of his fixed period, return fares will also be paid.

Applications, quoting Appointment No. 130/324 and stating full name, place, date and year of birth, nationality, marital state, present employment, particulars of qualifications and experience and war service, if any, accompanied by the names of three professional persons willing to act as referees and copies of not more than four testimonials, should reach the undersigned from whom further particulars may be obtained, not later than January 25, 1958.

A. SHAVITSKY,
Chief Scientific Liaison Officer.
Australian Scientific Liaison Office.
Africa House, Kingsway, London, W.C.2.

BRITISH COLUMBIA RESEARCH COUNCIL

OPERATIONAL RESEARCH

The British Columbia Research Council has a vacancy for an experienced Operational Research Scientist. Applicants should be not more than 35 years of age and should be actively engaged in Operational Research. The Council's laboratories are located on the campus of the University of British Columbia. The Council is engaged in industrial research and works very closely with the University.

Applicants wishing further information regarding the position should write to Dr. G. M. Shrum, Director, British Columbia Research Council, Vancouver 8, B.C.

IMPERIAL COLLEGE

LONDON, S.W.7

Applications are invited for the post of Nuffield Investigator in the Metallurgy Department. Applicants should have a degree in metallurgy, chemistry or physics and experience in research. The Investigator will be required to conduct research on his own account and to help in running the Nuffield Research Group in extraction metallurgy. Starting salary in range £900 to £1,200 per annum plus F.S.S.U., depending on qualifications and experience.

Applications, with curriculum vitae, to Professor F. D. Richardson at above address, before February 15, 1958.

ROWETT RESEARCH INSTITUTE

Scientific Officer for research in mineral metabolism, with special reference to Vitamin D. Good honours degree or equivalent in Chemistry, agricultural chemistry or biochemistry with postgraduate research experience to Ph.D. level. Salary scale (men), £595 to £1,050 per annum; (women) £595 to £974 per annum. F.S.S.U. superannuation.

Applications, stating date of birth, with particulars of education and experience, together with the names of three referees, should be sent to the Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire, as soon as possible.

UNIVERSITY COLLEGE OF GHANA

Applications are invited for Lectureship in Chemistry. Salary £950 by £50 to £1,600 per annum, entry point determined by qualifications and experience. Family allowance £100 per annum per child (maximum £500 per annum). Outfit allowance £60. F.S.S.U. Passages for appointee, wife and maximum of five children, on appointment, normal termination and leave. Part-furnished accommodation at rent not exceeding 7.5 per cent of salary.

Detailed applications (six copies), naming three referees, by January 31, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

PRINCIPAL AND SENIOR SCIENTIFIC OFFICERS

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE. To lead small teams carrying out original research in electronics. These deal with a wide variety of interesting problems which arise in nuclear physics and which cannot be solved by presently available techniques and equipment.

Applicants should have a first- or second-class honours degree, preferably in physics or electrical engineering, and should have conducted independent research in suitable aspects of electronics. These include ultra-fast time measurements, general electronic circuit design, transistor circuit design, information handling techniques, and the design of special electronic tubes.

Salary: P.S.O., £1,460 to £2,080 per annum; S.S.O., £1,215 to £1,425 per annum.

Contributory superannuation scheme. A house or assistance towards legal expenses on house purchase will be available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at above address. Please quote ref. 1647/34.

UNIVERSITY OF BRISTOL

Applications are invited for the post of Assistant Lecturer (Grade III) or Junior Fellow in (Veterinary) Pharmacology. Veterinary qualifications desirable but not essential. Initial salary £700 by £50 to £850 per annum according to qualifications and experience, together with superannuation and children's allowances. The successful candidate will be expected to devote much of his time to research. The post would be suitable for a candidate who wishes to read for a higher degree.

Further particulars may be obtained from the undersigned, to whom applications, with the names of three referees, should be sent not later than January 15, 1958.

H. C. BUTTERFIELD,
Registrar and Secretary.

UNIVERSITY COLLEGE OF WALES

ABERYSTWYTH

Applications are invited for the post of Director of the Welsh Plant Breeding Station, Aberystwyth, Cardiganshire. The appointment, which will take effect from October 1, 1958, will be in the grade of Deputy Chief Scientific Officer in the Agricultural Research Service at a salary within the scale of £2,400 by £100 to £2,700.

Further particulars can be obtained from the Registrar, to whom applications should be sent by January 31, 1958, together with the names and addresses of three referees.

UNIVERSITY OF MANCHESTER

Applications are invited from graduates of a British University for the post of Administrative Assistant in the Department of Physics in the Faculty of Science. Initial salary between £700 to £850 per annum according to age and qualifications. Membership of F.S.S.U. and children's allowance scheme. Duties to begin as soon as possible.

Applications should be sent not later than January 11, 1958, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained.

WEST AFRICAN COCOA RESEARCH INSTITUTE

Senior Research Staff are required for the following specialist posts graded from Scientific Officer to Senior Principal Scientific Officer. Senior Plant Breeder, Principal Scientific Officer or Senior Principal Scientific Officer; Senior Plant Physiologist, Principal Scientific Officer or Senior Principal Scientific Officer; Senior Agronomist, Principal Scientific Officer or Senior Principal Scientific Officer. In gross contract salary range £2,080 to £2,200 for Principal Scientific Officer and £2,350 to £2,650 for Senior Principal Scientific Officer. Agricultural Chemist, Scientific Officer or Senior Scientific Officer. In gross contract salary range £1,290 to £1,590 for Scientific Officer and £1,640 to £2,020 for Senior Scientific Officer. Gratuity at the rate of £12 10s. for each month of satisfactory service. Free passages on appointment and leave for officer, wife and up to three children under 18 years of age. The Institute has stations in Ghana and Nigeria, situated in pleasant, healthy residential areas with good amenities. Candidates must possess at least a second-class honours degree with considerable suitable postgraduate experience.

For further details apply to Director of Recruitment, Colonial Office, London, S.W.1, giving briefly age, qualifications and experience, quoting BCD.197/200/021.

ESSEX EDUCATION COMMITTEE

SOUTH-EAST ESSEX TECHNICAL COLLEGE LONGBRIDGE ROAD, DAGENHAM

Required as soon as possible: Assistant, Grade B, for Mathematics. Applicants should have a good honours degree. Salary: £650 by £25 to £1,025 per annum with additions for degree or equivalent qualification, training and London allowance. Increments within scale allowed for teaching service, War/National Service, and approved industrial experience.

Details and application forms (stamped addressed foolscap envelope), from the Clerk to the Governors at the College.

ROYAL MILITARY COLLEGE OF SCIENCE, Shrivenham, Berkshire, requires male Senior Lecturers or Lecturers in Mathematics, Chemistry, Civil or Mechanical Engineering, Electrical Engineering, Radar and Telecommunications and Engineering Physics for teaching at university level; good facilities for research. Qualifications: Appropriate first- or second-class honours degree; teaching experience an advantage and knowledge of application of subject to Service matters useful. Age: Minimum for Senior Lecturer (normally) 26, for Lecturer 21. Salary: Senior Lecturer, £1,130 to £1,330; Lecturer, £595 to £1,050. Starting salary allows credit for approved postgraduate experience and National Service. Superannuable under F.S.S.U. with good prospects of permanency. Quarters in residential officers' mess for single men. Possibility of houses at economic rent for married men after waiting period.—Particulars and forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A364/7A.

D.S.I.R. ROAD RESEARCH LABORATORY, Harmondsworth, Middlesex, requires Physicists for research on: (1) rheology of solid-liquid systems and viscous and visco-elastic fluids to provide basic information for design of bituminous road mixtures; (2) physical properties of concrete including various aspects of its rheology, effect of changes on construction procedures and properties of hardened concrete. Varied and interesting work carried out in laboratory and field, providing satisfying sense of achievement in solving the many problems involved; also contacts with other research physicists, chemists, engineers and mathematicians, and eminent practising physicists at home and abroad. Posts in Scientific Officer or Senior Scientific Officer grades, requiring first- or second-class honours degree in physics or equivalent. For Senior Scientific Officer posts some research experience necessary. Salary range £615 to £1,370 (men). Women's pay slightly less. Equal pay scheme. Normal prospects of promotion to Principal Scientific Officer in mid-thirties (range up to £2,000 with posibilities of higher posts). Opportunities for early establishment, with superannuation. Five-day week.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.362/7A.

BIOCHEMIST (SENIOR OR BASIC GRADE) required. Candidates should possess a B.Sc. degree with honours in chemistry or biochemistry (or an equivalent qualification). Whitley Council salary scale.—Applications, with names of two referees, to Group Secretary, Royal Hospital, Wolverhampton.

GAS COUNCIL MIDLANDS RESEARCH STATION

Applications are invited from suitably qualified Chemists, Physicists, Chemical Engineers and Fuel Technologists for appointments in this newly established research station, which is concerned with novel methods of gas manufacture and with improving the use of gas, especially in industry. Candidates should hold, at least, a second-class honours degree of a British university, or an equivalent qualification and be free of National Service liabilities. Postgraduate research experience is an advantage. Men and women who after experience show the qualities of effective leadership of investigations will be paid salaries commensurate with these attributes. The Station is in Solihull in Warwickshire and is within easy reach of Birmingham.

Applications, in writing, detailing education, qualifications and experience, should be sent to the Industrial Relations Officer, West Midlands Gas Board, 6 Augustus Road, Edgbaston, Birmingham, 15.

J. SWAN,
Secretary to the Board.

UNIVERSITY OF OTAGO
DUNEDIN, NEW ZEALAND

A vacancy exists in the Department of Physiology for the position of Senior Lecturer or Lecturer. Salary scales: Senior Lecturer, £1,790 to £2,090 per annum (medically qualified), £1,315 to £1,615 per annum (science graduate); Lecturer, £1,290 to £1,590 (medically qualified), £1,025 to £1,275 per annum (science graduate).

Further particulars are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in New Zealand and London on January 20, 1958.

LABORATORY TECHNICIAN REQUIRED for medical research—mainly chemical and histological. Salary £420 to £480 per annum, according to age and experience (with pension scheme) but applicants with I.M.L.T. qualification will be paid in accordance with Whitley Council scale for Health Services. Applications from Student or Junior Technicians also considered.—Written applications to the Secretary, The Welsh National School of Medicine, 34 Newport Road, Cardiff.

OXFORD. LADY MARGARET HALL offers two Visiting Fellowships in Science, of £500 non-resident with certain dining rights, for women graduates from the Commonwealth or the U.S.A. during 1958-61, each tenable for one year.—Further particulars may be obtained from the Principal, to whom applications should be sent by May 1, 1958.

APPOINTMENTS VACANT

CHEMIST WITH HONOURS DEGREE OR A.R.I.C. required by London firm of Chartered Patent Agents to assist in patent work in chemical and other fields. Previous patent experience and knowledge of German preferred. The post offers excellent opportunity of entering a profession requiring high standard of ability and affording varied and interesting work of technical and legal nature. Prospect of early promotion to senior position and eventual partnership. Five-day week. Pension scheme.—Write details, age, qualifications and salary required to Abel & Imray, Quality House, Quality Court, W.C.2.

OXO LIMITED INVITE APPLICATIONS for the appointment of Technical Sales Correspondent for their Medical Division. This is an important and responsible appointment and will entail the preparation of technical literature. A substantial salary is offered and there is a superannuation scheme. Candidates, who must be prepared to work in the City of London, must: (a) be under 45 years of age; (b) have an expert knowledge of bacteriology and culture media; (c) be an experienced and capable journalist; (d) possess a sales outlook.—Applications, which will be considered in strict confidence, should give the fullest details and should be addressed to the Sales Manager (M.O.), Oxo Limited, Thames House, Queen Street Place, London, E.C.4.

RESEARCH ASSISTANT REQUIRED FOR corrosion and electro-chemical research work by a light engineering Company in the West Middlesex area. Candidates should be at least 21 years of age and possess some knowledge of analytical methods.—Applications, stating full details of experience and qualifications and salary required, should be sent to the Personnel Manager, Box No. 993, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2, quoting reference No. 40/57.

THE NUCLEAR POWER PLANT CO. LTD.
requires
MATHEMATICAL PHYSICISTS
or
APPLIED MATHEMATICIANS

to work on interesting problems associated with the design of Commercial Nuclear Power Stations throughout the world. A second-class honours degree is the minimum qualification and for certain appointments some knowledge of reactor or nuclear physics is desired.

In appropriate cases deferment of National Service will be obtained. Married men will be given assistance with house purchase.

Applications, giving age, qualifications and experience should be sent to:

The Secretary,
The Nuclear Power Plant Co. Ltd.,
Booths Hall,
Knutsford,
Cheshire.

Quoting reference N./PHYS/31.

ELECTRONIC COMPUTERS

FERRANTI LTD.
WEST GORTON,
MANCHESTER, 12
requires

ELECTRONIC ENGINEERS AND PHYSICISTS

Although graduates are preferred for these appointments, consideration will be given to other applicants provided they are able to show from past experience their capabilities for work in this field.

These vacancies are of a particularly interesting nature as the successful applicants will work in conjunction with experienced computer engineers on advanced circuit techniques in the main Computer Development Laboratory where they will have ample opportunity of acquiring a wide and up-to-date knowledge of computer work.

The Company operates a Staff Pension Scheme and an Assurance Scheme for Dependants.

Forms of application can be obtained from T. J. Lunt, Staff Manager, Ferranti Limited, Hollingwood, Lancs. Please quote reference GGS.

PHYSICAL CHEMISTS OR PHYSICISTS for the Research Organization of Turner Brothers Asbestos Co. Ltd., to study and standardize chemical and physical test methods for use in the various Research Departments and factory processes. The range of investigation envisaged includes textiles, rubber products, synthetic resin manufactures, glass making, plastics and associated materials. The posts offer interesting work in an expanding organization. The situation of the Research Headquarters is in Rochdale and the study would be carried out there. Pension benefits, canteen and recreational facilities are available. All applications will be treated as strictly confidential.—Apply, stating age, education and experience, to the Personnel Manager, Turner Brothers Asbestos Co. Ltd., Spotland, Rochdale, Lancashire.

THE IMPERIAL TOBACCO COMPANY Limited wishes to recruit a young graduate or A.R.I.C. for its Research Department in Bristol. The vacancy is for an Organic Chemist to join a team working on problems which call for versatility rather than specialist knowledge. The work will include development of methods for quantitative analysis, isolation of pure compounds from complex mixtures and synthesis. The appointment will be pensionable with starting salary, according to qualifications, etc.—Applications should be made to the Staff Secretary, Imperial Tobacco Co., Ltd., Bristol, 1.

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Applications should be addressed to the Secretary, Hosiery and Allied Trades Research Association, 4 First Avenue, Sherwood Rise, Nottingham.

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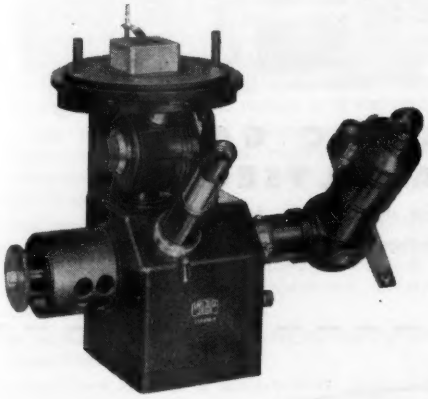

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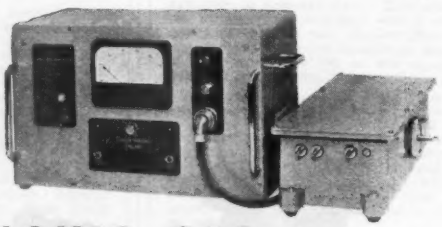

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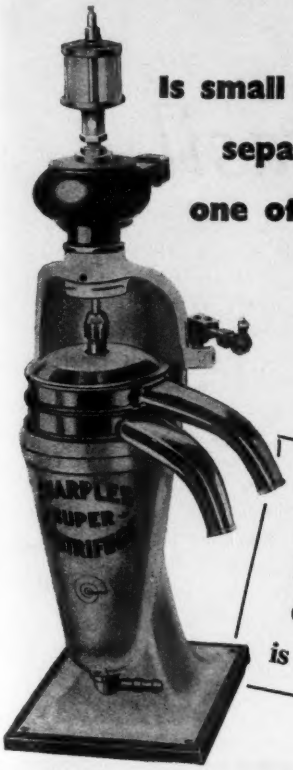

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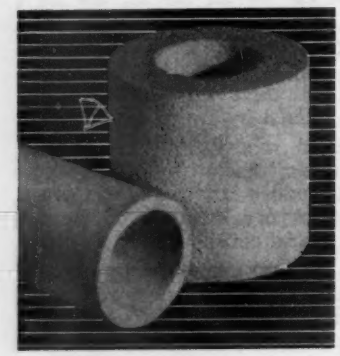

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